FIELD, KATE • BELL'S TELEPHONE

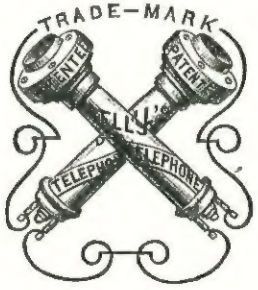
THE HISTORY OF

BELL'S

TELEPHONE.

EDITED BY

KATE FIELD,



Third Thousand.

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The Queen and the Telephone.

"OSBORNE, *Jan.* 16, 1878.

"MY DEAR SIR,

"I hope you are aware how much gratified and surprised the Queen was at the exhibition of the Telephone here on Monday evening.

"Her Majesty desires me to express her thanks to you and the ladies and gentlemen who were associated with you on the occasion.

"The Queen would like, if there is no reason against it, to purchase the two instruments which are still here, with the wires, &c., attached. Perhaps you will be so kind as to let me know to whom the sum due should be paid.

"I am, my dear Sir,

"Very faithfully yours,

"THOS. BIDDULPH."

"Prof. ALEX. GRAHAM BELL."

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THE

HISTORY OF BELL'S TELEPHONE.

In 1849, Alexander Melville Bell, of Edinburgh, Scotland, first published a system of symbols by which scientists could define and compare the sounds of all languages. In previous alphabets the plan had been adopted of giving to each sound a separate arbitrary character, so that as many characters were required as there were sounds to be represented. Critical analysis of several languages disclosed the fact that the known elements of speech could be numbered by hundreds, while theoretically they could be increased indefinitely. A universal alphabet therefore seemed to be impossible from the large number of characters required, and in 1854 the conference of European philologists which assembled at the Prussian Embassy in London, under the Presidency of Chevalier Bunsen, for the purpose of framing a universal alphabet, abandoned the matter as impracticable. In the same year Mr. Melville Bell received from the Royal Society of Arts in Edinburgh a medal for his discovery of a system of stenography, the characters of which represented the positions of the human organs of speech. Spurred on by the importance given to the subject by the conference of philologists and by other scientists, Mr. Bell persevered in his work until 1864, when he produced his system of symbols now popularly known as "visible speech." Sir David Brewster, Alexander J. Ellis, Esq., Sir Charles Wheatstone, Professor De Morgan, Prince Lucien Bonaparte and others were immediately attracted by the simplicity, novelty and practicability of the new development, which was universally adopted for scientific and educational purposes.

In 1870, Mr. Bell accepted an invitation to lecture before the Lowell Institute of Boston, United States, and there suggested that the deaf and dumb might be trained to speak intelligibly by means of his symbols. Impressed with the feasibility of this idea, the Boston Board of Education prevailed upon Alexander Graham Bell, the son of the inventor, to visit America in 1871 and try the experiment. It was so successful that the great majority of the institutions in the United States for educating the deaf and dumb have adopted the system, and hundreds of deaf mutes can now speak intelligibly. On account of Mr. Graham Bell's intimate knowledge of the mechanism of speech, as demonstrated by his wonderful success with the deaf and dumb, he was appointed, in 1873, Professor of Vocal Physiology in the Boston University. For many years Mr. Bell had been a profound student in acoustics, the love of this branch of science seeming to have been hereditary in his family, three generations having devoted their lives to it. To this inherited study, and ten years of elaborate experiment, is due what Sir William Thomson rightly calls "one of the most interesting of the scientific inventions made in this century, or that has ever been made in the history of science."

There were Telephones before that of Mr. Alexander Graham Bell, but those Telephones differed from Mr. Bell's in the same sense as a series of claps of the hand differs from the human voice. They were instruments in which, by electric action, a succession of shocks was produced by suddenly stopping and starting the electric currents. Mr. Bell conceived the original idea of giving continuity to the shocks, and of producing claps which would be in simple proportion to the motion of the air created by the voice, and of reproducing that effect at the remote end of the telegraph wire, be that end far or near, with a motion so nearly similar to the motion of the air caused by the voice as that not only is the articulation of the voice heard, but the different qualities of different voices are distinguished. John Smith in London converses with Thomas Jones in Liverpool as easily as though the distance between them could be measured by a few yards of speaking

tube. No more time is required in the one instance than in the other.

The fall of an apple inspired the theory of gravitation; the twitching of a frog's leg led to the electric telegraph, and from equally small beginnings comes Mr. Bell's Telephone. While carrying on experiments in regard to the relation of electricity and magnetism, Professor Charles Page, of Salem, Massachusetts, investigated the production of sound by electric current, and, in 1837, published the result of his researches in an article entitled "Galvanic Music," which attracted so much attention in America and Europe that numerous investigators went to work to discover the cause of many curious electric sounds. Mr. Bell's own researches in electrical telephony began with the artificial production of musical sounds. Striving to perfect his ingenious system of teaching, it occurred to Mr. Bell that if, instead of presenting to the eye of the deaf mute a system of symbols, he could make visible the vibrations of the air, the apparatus might be used as a means of teaching articulation. Experimenting with different instruments Mr. Bell found great assistance from the phonautograph, which had just been greatly improved by Mr. Maurey, a student of the Boston Institute of Technology. He had succeeded in vibrating by the voice a stylus of wood, about a foot in length, which was attached to the membrane of the phonautograph; and with this he obtained enlarged tracings of the vibrations of the air, produced by the vowel sounds upon a plane surface of smoked glass. Mr. Bell traced a similarity between the manner in which this piece of wood was vibrated by the membrane of the phonautograph, and the manner in which the ossiculæ of the human ear were moved by the tympanum membrane. This discovery led him to construct a phonautograph modelled closely upon the mechanism of the human ear, calling to his aid Dr. Clarence J. Blake, a distinguished aurist of Boston, who suggested the use of the human ear itself, and prepared a specimen for this purpose. The stapes were removed, and, being lighter, a stylus of hay, about an inch in length, was attached to the end of the incus. Upon moistening the membrana tympani and the auriculæ with a mixture

of glycerine and water, the necessary mobility of the parts was obtained, and upon singing into the external artificial ear, the stylus of hay was thrown into vibration, and tracings were obtained upon a plane surface of smoked glass passed rapidly underneath. While engaged in these experiments, Mr. Bell's attention was arrested by observing the wonderful disproportion which existed between the weight of the membrane and that of the bones vibrated by it. "If a membrane as thin as tissue paper," argued Mr. Bell, "can control the vibration of bones which, compared to it, are of immense weight and size, why may not a larger and thicker membrane vibrate a piece of iron in front of an electro-magnet? If this be so, the complication of steel rods, suggested by the harp arrangement, can be done away with, and a simple piece of iron attached to a membrane take their place." Action followed thought. Employing apparatus by which he had been producing undulatory currents of electricity for the purpose of multiple telegraphy, Mr. Bell attached a rod loosely by one extremity to the uncovered pole of a magnet, and fastened the other extremity to the centre of a stretched membrane of goldbeater's skin. He supposed that upon speaking in the neighbourhood of the membrane it would be thrown into vibration and cause the steel rod to move in a similar manner, thereby occasioning undulations in the electrical current that would correspond to the variations in the density of the air during the production of sound; and further, that the change in the intensity of the current at the receiving end would cause the magnet there to attract its rod so as to copy the motion imparted to that at the sending end. Mr. Thomas A. Watson, Mr. Bell's assistant, declared, during the experiment, that he heard a faint sound proceed from the instrument at which he listened, but Mr. Bell was less fortunate. Persevering in his researches, Mr. Bell at last determined to reduce the size and weight of the spring attached to the diaphragm as much as possible, and thereupon glued a piece of clock-spring, about the size and shape of his thumb-nail, to the centre of the diaphragm. This produced audible results, and on the model thus obtained, Mr. Bell constructed his Telephone, which consisted of

a permanent magnet with a coil of wire round it and an iron plate in front. The vibration of the voice caused the vibration of the iron plate. That vibration produced a current of electricity; the current of electricity caused a variation of power in the magnet in the distant instrument; the variation of power in the distant magnet caused the iron plate in front of the magnet to vibrate, and that vibration produced a sound. The voice was converted into electricity at one end, and electricity became voice at the other end.

Such was the instrument that Mr. Bell sent to the Centennial Exhibition at Philadelphia, where it attracted the attention of electricians, and inspired the following official report, signed by Sir William Thomson and others:—

"Mr. Alexander Graham Bell exhibits apparatus by which he has achieved a result of transcendent scientific interest—the transmission of spoken words by electric currents through a telegraph wire. To obtain this result, Mr. Bell perceived that he must produce a variation of strength of current in the telegraph wire as nearly as may be in exact proportion to the velocity of a particle of air moved by the sound, and he invented a method of doing so—a piece of iron attached to a membrane, and thus moved to and fro in the neighbourhood of an electro-magnet—which has proved perfectly successful. The battery and wire of this electro-magnet are in circuit with the telegraph wire and the wire of another electro-magnet at the receiving station. This second electro-magnet has a solid bar of iron for core, which is connected at one end by a thick disc of iron to an iron tube surrounding the coil and bar. The free circular end of the tube constitutes one pole of the electro-magnet, and the adjacent free end of the bar core the other. A thin circular iron disc, held pressed against the end of the tube by the electric magnetic attraction, and free to vibrate through a very small space without touching the central pole, constitutes the sounder, by which the electric effect is reconverted into sound. With my ear pressed against this disc I heard it speak distinctly several sentences. . . . I need scarcely say I was astonished and delighted; so were others, including some judges of our group, who witnessed the experi-

ments, and verified with their own ears the electric transmission of speech. This, perhaps the greatest marvel hitherto achieved by the electric telegraph, has been obtained by appliances of quite a home-spun and rudimentary character. With somewhat more advanced plans and more powerful apparatus, we may confidently expect that Mr. Bell will give us the means of making voice and spoken words audible through the electric wire to an ear hundreds of miles distant."

Surprised by so enthusiastic a verdict, Mr. Bell returned to his experiments with renewed energy, and on the 9th of October, 1876, there took place the first conversation ever carried on by word of mouth over a telegraph wire. Telephones were placed at either end of a telegraph line, owned by the Walworth Manufacturing Company, extending from their office in Boston to their factory in Cambridgeport, a distance of about two miles. The company's battery, consisting of nine Daniels cells, was removed from the circuit, and another of ten carbon elements substituted. Articulate conversation then took place through the wire. The sounds, at first faint and indistinct, became suddenly quite loud and intelligible. Mr. Bell in Boston, and his assistant, Mr. Watson, in Cambridge, took notes of what was said and heard, and the comparison of the two records is most interesting, as showing the accuracy of the electrical transmission :—

BOSTON RECORD.	CAMBRIDGEPORT RECORD.
Mr. Bell—What do you think was the matter with the instruments?	Mr. Bell—What do you think is the matter with the instruments?
Mr. Watson—There was nothing the matter with them.	Mr. Watson—There is nothing the matter with them.
B.—I think we were both speaking at the same time.	B.—I think....at the same time.
W.—Can you understand anything I say?	W.—Can you understand anything I say?
B.—Yes; I understand everything you say.	B.—Yes; I understand everything you say.
W.—The reason why you did not hear at first, was because there was a relay in the circuit.	W.—The reason why it did not work at first was because there was a relay in the circuit.
B.—You may be right, but I found the magnet of my telephone touching the membrane.	B.—You may be right, but I find ....that my....touches the membrane.
W.—I cut this relay out, and then the sounds came perfectly.	W.—I cut the relay out, and then the sounds came out perfectly.
B.—I hear every syllable. Try something in an ordinary conversational voice.	B.—I hear every syllable. Try something in a conversational voice.

BOSTON RECORD.	CAMBRIDGEPORT RECORD.
W.—Shall I connect their battery in the circuit?	W.—Shall I connect their battery in the circuit?
B.—No; there is no necessity to connect their battery in the circuit, for the sounds come out quite loudly.	B.—No; there is no necessity for putting their battery in the circuit, as the sounds come out quite loudly.
W.—I am now talking in quite a low tone of voice.	W.—I am now talking in quite a low tone of voice.
B.—The sounds are quite as loud as before, and twice as distinct.	B.—The sounds are quite as loud as before, and quite as distinct.
W.—Cut out the battery, and then talk.	W.—Cut out the battery, and then talk.
B.—All right. I will cut out the battery now if you will keep listening.	B.—All right. I will cut out the battery now if you will keep listening.
[Here an interruption occurred, and after a short time Mr. Bell said:]	
B.—I thought you were going to say something.	B.—I thought you were going to say something.
W.—Is the battery cut out?	W.—Is the battery cut out?
B.—No, but I will do it now.	B.—No, but I will do it now.
[Battery having been cut out, Mr. Bell continued.]	
B.—Do you hear anything now?	
[Battery replaced.]	
B.—Did you hear anything?	B.—Did you hear anything?
W.—No, not a sound.	W.—No, not a sound.
B.—Say something to me when I cut out the battery again.	B.—Say something to me when I cut out the battery again.
[Battery cut out.]	
W.—.....	W.—I could not hear a sound when the battery was cut out.
[Battery replaced.]	
B.—I fancy I heard a trace of your voice.	B.—I fancy I heard a trace of your voice.
W.—Shall I put on our battery to see if it increases the effect?	W.—Shall I put on their battery to see if it increases the effect?
B.—I'll tell you what we'll do. We'll take off our battery and put on theirs, as before.	B.—I'll tell you what we'll do. We'll take off our battery altogether and put on theirs, as before.
[The company's battery having been placed in circuit, faint and indistinct sounds were heard at the Boston end, and then came the intelligible sentence.]	
W.—Is our battery off?	W.—Is our battery off?
B.—Yes, our battery is off. What have you been doing? The sounds were quite soft at first, but now they are quite loud.	B.—[Very indistinct — unintelligible.]
B.—Shall I put on our battery again?	
W.—[Indistinctly heard.] That was very indistinct. Put on our battery.	W.—That was very indistinct. Put on our battery.
[Original battery replaced.]	
B.—We may congratulate ourselves upon a great success.	B.—We may congratulate ourselves on our great success.

BOSTON RECORD.	CAMBRIDGEPORT RECORD.
W.—Both batteries are on now. [Another sentence heard indistinctly.]	W.—We deserve success. Both batteries are on now.
B.—Repeat the last sentence.	B.—Repeat the last sentence.
W.—Both batteries are on now.	W.—Both batteries are on now.
B.—I understood that before, but I thought you said something else.	B.—I understood that before, but I thought you said something else.
W.—Remove their battery, please.	W.—Reverse your battery, please.
B.—All right; our battery is the only one on now.	B.—All right; our battery is the only one on now.
W.—I have put battery cells on here.	W.—I have six Daniells cells on here.
B.—How many cells have you there?	B.—How many cells have you on there?
W.—S—i—x—six.	W.—S—i—x—six.
B.—Please whisper something to me.	B.—Please whisper something to me.
W.—[Sound of the whisper clearly audible, but the utterance unintelligible.]	W.—I am now whispering.
B.—I could hear you whispering, but could not understand what you said.	B.—I could hear you whispering, but could not understand what you said.
W.—Perhaps we have got the batteries opposed to one another. Had you not better reverse your battery and see what the matter is—or rather what the effect is?	W.—Perhaps we have got the batteries opposed to one another. Had you not better reverse yours, and see what the effect is?
B.—I will try the effect of reversing my battery.	B.—I will try the effect of reversing my battery.
[Battery reversed.]	
B.—Is this any better?	B.—Is this any better?
W.—That sentence was accompanied by that curious crackling sound.	W.—Much fainter, accompanied by that curious bubbling sound.
B.—Yes, I hear it too.	....
B.—What time is it by your watch?	....
[Battery again reversed.]	
W.—What are you doing? I have not heard anything except ..... for quite a while.	W.—What are you doing? I haven't heard anything except that bubbling sound for quite a while.
B.—I asked you what time it was by your watch. Perhaps you hear me better now, because I have reversed the battery again.	B.—I asked you .... because I ....
W.—My battery is now cut out.	W.—My battery is now cut out.
B.—Don't you think we had better go home now?	B.—Do you think we had better go home?
W.—Yes; but why does your talking come out so much fainter now?	W.—Yes; but why does your talking come out so much fainter now?
[Mr. Bell here placed the magnet of the telephone nearer to the membrane]	
B.—Because I had moved the magnet further away from the membrane.	B.—Because I moved the magnet further away from the membrane.
W.—That was very much more distinct.	W.—That was very much more distinct.
B.—Will you try to understand a long sentence if I speak right on?	B.—Will you try to understand a longer question if I speak right on?
W.—I will.	W.—I will.

BOSTON RECORD.	CAMBRIDGEPORT RECORD.
B.—A few minutes ago I heard a fire-engine pass by the door. I don't know where the fire is, but the number of the box is 196.	B.—A few minutes ago I heard a fire-engine go past the door. I don't know where the fire is, but the number of the box is 196.
W.—The time by my watch is five minutes past ten. Had I not better go into Boston?	W.—The time by my watch is five minutes past ten. Had I better not go into Boston?
B.—Yes. I think it is time to stop now.	B.—Yes. I think it is time to stop now.
W.—Shall I go to Exeter Place?	W.—Shall I go to Exeter Place?
B.—Yes; but look in here on your way, in case I have not gone.	B.—Yes; but look in here on your way, in case I have not gone.
W.—Let us talk conversationally without noting.	W.—Let us talk conversationally without noting.

Conversation was then carried on for about half an hour with the utmost freedom, and the experiment closed.

The first public exhibition of the Telephone was given in Salem, eighteen miles from Boston, on the evening of February 12th, 1877, before an audience of 500. The wires were brought into the hall of the Essex Institute, and Mr. Watson, with assistants, was stationed in a house in Boston, ready to communicate with Mr. Bell in Salem. After a brief lecture by the inventor, an intermittent current was sent from Boston, which caused a noise from the Telephone very similar to that of a horn. The Morse telegraph alphabet was sent by musical sounds, and could be heard throughout the hall. A telephonic organ was then put into operation in Boston. "Should Auld Acquaintance be Forgot" and "Yankee Doodle" were heard and applauded. At this point Mr. Bell asked Mr. Watson for a song, and "Auld Lang Syne" came from the mouth-piece of the instrument almost before his words were ended. Later Mr. Watson made a speech to the audience, which was heard thirty-five feet distant. Mr. Watson was asked if he heard the applause. The answer came, "I was not listening. Try again." The applause was given, and its receipt was at once acknowledged in Boston.

The results of the experiments were "telephoned" to the *Boston Globe*, and the despatches constitute the first ever sent to the public press by this novel agency.

On the 4th of May following, there were strange scenes in the Boston Music-hall. Going to the small telephone box, with its slender wire attachments, Mr. Bell coolly asked, as

though addressing some one in an adjoining room, "Mr. Watson, are you ready?" Mr. Watson, five miles away in Somerville, promptly answered in the affirmative, and soon was heard a voice singing "America." Then followed the Portuguese Hymn, to the amazement of a hushed audience. Going to another instrument connected by wire with Providence, forty-three miles distant, Mr. Bell listened a moment, and said, "Signor Brignoli, who is assisting at a concert in the Providence Music-hall, will now sing for us." In a moment the cadence of the tenor's notes rose and fell, the sound being faint, sometimes lost, and then again audible. Later, a cornet solo, played in Somerville, was very distinctly heard. Still later, a three-part song floated over the wire from the Somerville terminus, and Mr. Bell amused his audience exceedingly by exclaiming, "I will switch off the song from one part of the hall to another, so that all can hear." Shunting music coming over a wire forty-three miles long, as though it were a railway train! This shunting was done effectively through a central telephone suspended in the middle of the hall. Not long after, the Telephone was put to a remarkable test at Newhaven, Connecticut, in a company including members of the faculty of Yale College. The wires were extended from a Telephone through several apartments into a room where sixteen persons stood in two ranks. The first person in each rank took the end of one wire, and the eighth person in each touched wires attached to the magnet of a second instrument, the tones of the voice being sent successfully through these sixteen human bodies without any perceptible shock. At the Newport torpedo station, in Rhode Island, speaking has been carried on through a line, including five miles of submerged cable and an equal length of land wire. Siemens' resistance coils were added, 2,000 ohms at a time, until 12,000 ohms were introduced in the circuit without interfering with the transmission of speech. The importance of this test will be understood when it is remembered that the resistance of the Atlantic Cable is equal to 7,000 ohms only. The experiments at Newport were continued by the addition of a total resistance of 30,000 ohms, but beyond

12,000 ohms the sound was found to diminish in intensity. Mr. Bell states that the *maximum* amount of resistance through which the undulating current will pass, and yet retain sufficient force to produce an audible sound at the distant end, has yet to be determined. In the laboratory he has conversed through a resistance of 60,000 ohms. The longest length of practical telegraph line spoken through thus far is 600 miles.

At Montreal five Telephones were recently attached to one end of a line ten miles in length, while a single Telephone was connected with the other end. Speaking and singing from the single Telephone were heard simultaneously by five listeners at the instruments in Montreal, and questions put indifferently through any of the five Telephones were immediately answered from the other end of the line. Again, in the same town, a line extending from one private house to another had one Telephone at one end and three Telephones at the other. Two of the three were held by singers, while the person holding the third stood on the sounding-board of the piano. The combined effect of vocal duet and instrumental accompaniment was distinctly heard through the single Telephone at the other end of the line. At Hamilton, Canada, nine Telephones were placed on the same circuit, on a line connecting three private houses. Speaking or singing from any one of the Telephones came distinctly to all the listeners at the other houses on the circuit. "Auld Lang Syne" and "Old Hundred," sung at the same time at two of the houses, were heard simultaneously at the third. On holding a Telephone against the sounding-board of a piano at one house, the music was enjoyed by six listeners at the other houses. On one occasion an attempt was made to speak at a distance of 125 miles, but the wire in running beside numerous other busy wires stretched on the same poles, gathered up the myriad sounds into a din that filled the Telephone with the click and clang of a boiler-maker's rivetting shop. The voice was drowned in consequence. The Telephone seems to defy distance, but requires a comparatively silent line; because of this latter fact, it has been feared that it could not be prac-

ticable over any wire having other wires for neighbours; but an eminent electrician, Mr. Preece, of the Post Office, has discovered a means by which this serious obstacle is entirely overcome.

The first practical application of the Telephone was made in May, 1877, by the Water Board of Cambridge, Massachusetts, who established telephonic communication with the waterworks at Fresh Pond in order to facilitate the sending of messages. Now more than 500 houses in New England hold telephonic communication, and more than 6,000 Telephones are in operation in the United States. Gentlemen in their libraries give orders to clerks in their offices, fire brigades have called the Telephone into requisition, and it is used extensively in the mines of Pennsylvania, Nevada, and California. In fact, the invention has passed out of the region of speculation, and ingenious minds are constantly finding new work for it to do. Its application in diving is an accomplished fact. The size of the Telephone-box is of no consequence, and a complete instrument may be made not larger than the palm of the hand. This is easily attached to the diver's armour in a way to allow him at any time to speak with his assistants above.

Although Mr. Bell has been but a few months in England, his invention has already commanded the attention it deserves. There has been telephonic communication between this island and Jersey, between Dover and Calais, between Dublin and Holyhead. Business houses are similarly connected with private residences, and on the 5th of November some remarkable experiments were made at the Prescot Colliery of the Wigan and Whiston Coal Company, near Liverpool, under the personal superintendence of Sir William Thomson. In these experiments 600 yards of ordinary electric wire were used, the ends in one instance being at the bottom of the pit, while the other ends to which the tubes or trumpet-like orifices, which resemble ordinary stethoscopes, were attached, were brought into the office of the company, which is some distance from the pit's mouth. While one of the Government colliery inspectors and others went to the bottom of the pit, the

majority of the audience remained in the office. Complete success crowned the first experiment, which was merely to test the Telephone as a means of communication. Questions asked in the office were answered instantaneously from the pit. Even the cheering of the colliers at a distance from the instrument was distinctly heard; and those at the lower instrument stated that they not only heard the messages forwarded, but also the buzz of animated conversation. The instrument was then applied to the indicating overhead the anemometer below. Up to the present time the rate of the current of air in the passages of the mine could only be known by reading it off the register of the anemometer. By means of the Telephone the registry may be tested at any moment by a person above the mine. Deceit becomes impossible. It has been a common practice to remedy insufficient ventilation merely when the men have warning that an official is about to descend the shaft. The registration above is attained by having the air measurer always connected with a Telephone, and so adjusted that after a fixed number of revolutions the instrument may act on a spring which vibrates against the Telephone, and setting it in action, enables the overseer above ground to know at what rate of current the air is running in the mine. This was done to the complete satisfaction of Mr. Hall, the inventor of the anemometer. It was proved at the same time that the Telephone used to register the ventilation could be also used for communication with all parts of the mine by the same wire. Given one wire and the requisite number of Telephones, and a perfect record can be obtained of the quantity of air going into a mine, as well as perfect communication be established between the surface and the interior. It is hardly possible to conceive a greater benefit to colliers than this discovery entails.

During the experiments Sir William Thomson gave a short lecture on the Telephone to a double audience—one being in the mine and the other in the office—expressing his amazement at the great improvement which the instrument had undergone since first tested by him at Philadelphia in the presence of the Emperor of Brazil. If such admirable results

have been accomplished by the Telephone while, according to the inventor, it is still in embryo, what may not be hoped from the future?—*Reprinted, with additions, from "The Times" of November* 16, 1877.

THE TELEPHONE OF THE FUTURE.

(AN INTERCEPTED LETTER.)

LONDON, *February*, 1878.

DEAR ELLA,—The moment the Telephone reached England, Bob and I went to see it, and we've had it on the brain ever since. When the Western pioneer returned home to find that the Indians had burned his cabin and scalped his wife and seven small children, he remarked, "This is tew ridiculous!" My dear, this is precisely the effect made on the unregenerate mind by a first interview with the Telephone. The old proverb, "Parturiunt montes, nascitur ridiculus mus" is turned topsy-turvy, for a mouse brings forth a mountain! I sat down before a table on which stood a very small desk, at the top of which was an electric bell. On both sides of the desk, depending from iron arms, was a small pear-shaped wooden instrument, bearing a strong family resemblance to the stethoscope. The small end of each instrument was connected with a telegraphic wire. I was in the presence of the Telephone. "Is this all?" I asked. "All!" exclaimed the superintendent. "Isn't it enough, provided the object be attained? Isn't simplicity a charm in inventions as well as in people? Would you feel happier if the Telephone were the size of a steam-engine? Before you say another word, touch that electric bell, put one telephone to your ear and the other to your mouth." Feeling quite crushed at being so sat upon, I obeyed orders, and straightway I heard an unknown voice exclaim,—

"All right; what do you want?"

"Who are you?" I asked.

"I'm every inch a man, and by your voice I know that my questioner is a lady."

"How far away are you?"

"Half a mile."

"Will you whistle?"

"Certainly."

Sure enough, I heard with the utmost distinctness, "Whistle and I'll come to thee, my lad."

"Capital," I said. "Now a song, if you please."

Didn't I laugh when my unknown acquaintance sang, "Thou art so near and yet so far!"

"Why did you laugh?" asked the Invisible, at the conclusion of his song.

"Did you hear me? My mouth was some distance from the Telephone."

"I heard you perfectly. Now hear me breathe."

When that breath came to my ear I was startled, Ella. Then we whispered to each other, and finally the Invisible exclaimed, "Just one more experiment," and he kissed me! I heard him. I can't say honestly that this final experiment was as satisfactory in its results as the ordinary way of performing the operation. It is not likely to supersede old-fashioned osculation, but *faute de mieux*, it will serve. I am quite sure the young King of Spain resorted to it recently when, forced to leave Aranjuez and return to Madrid, he communicated telephonically with his *fiancée*.

Would you believe it, Ella? Three weeks later, when I next interviewed the Telephone, the Invisible, who had never seen me, and had only heard my voice during the short conversation I have repeated, began to laugh, and said, "I had the honour of kissing my fair questioner three weeks ago." This proves the wonderful delicacy of the instrument, and how impossible it will be to practise deception through it. Since then I have heard four-part singing, "sounding like distant music on the water," to borrow the happy expression of the Duke of Connaught, who was delighted with the effect. It's a singular fact that part singing which is by no means true, comes out beautifully at the distant end of the Telephone. Electricity has so exquisite an ear that it seems to harmonise all differences. It will be a good idea for im-

presarios to pass all their doubtful singers through the Telephone. They will never be out of tune, no matter how flat or sharp they start. Then, Ella, I've heard a solo and pianoforte accompaniment, with every note and word as audible as possible; I've heard bugle playing fifty miles distant that was charming, and I've heard an organ 130 miles away! Now I'm prepared for the deluge, or whatever Nature pleases. It's impossible to be surprised any more. Before long we shall sit down, fold our arms, and let electricity do everything for us. We'll go to bed and get up by electricity; we'll eat by electricity, and be saved the bore of knives and forks. We'll write by electricity, and see by the same means. Yes, you needn't open your eyes. I've just read of the electroscope, the province of which is to transmit waves of light by electricity. Combine it with the Telephone, and while two persons, hundreds of miles apart, are talking together, they will actually *see* each other! Won't this be fun? If your lover happens to be an amateur photographer, he'll take your picture, my dear, across the ocean! Only let electricity circumvent the Atlantic, and I'm its slave for life.

Professor Bell is quite a young man. He can't be more than thirty-six, and both Bob and I think him handsome. He is tall, well made, has dark hair, very expressive hazel eyes, and a mobile mouth. Fluent in conversation, he makes an interesting lecturer, and if he has as much energy as inventive ability, will soon make such improvements in the Telephone as to cause even his own hair to stand on end. It is in him.

People ask what the Telephone is good for. Almost everything, it seems to me. Banks are connecting their various branches; and that enterprising paper, the *Daily News*, has telephonic communication with the House of Commons. The instrument is used in mines, in diving, in connecting fire brigade and police stations. It will be admirable for coast-guard service, for ships, for communication on the battle-field. Just think of it! A man with a Telephone and a coil of wire can go up in a balloon, inspect the enemy's position, and give instant information to whoever is at the earth end of the wire.

Then in domestic life, I foresee the day when Telephone stations will be as frequent as telegraphic stations now are, and every house will be connected with the nearest station. When a lady wishes to go shopping, or to make purchases for the house, she will ask the stationmaster to connect her wire with Whitely, or Parkins and Gotto, or Madame White, or the butcher, or the baker. Thus from the depths of a comfortable armchair will she give her orders for the day. If she wishes to visit Mrs. Brown, she'll ask to be put in circuit with the dear creature, and the two will pull all their friends to pieces without the bother of taking a cab or ordering out the ever-unwilling coachman. Indeed, opera, theatre, and everything in general will be turned on like gas and water. For lovers the Telephone must be a sweet boon. Instead of serenading one's innamorata in cold or rain, with the probability of exciting the ire of Paterfamilias, the modern swain seated in his study, arrayed in dressing-gown and slippers, will play his plaintive flute into the Telephone, and *she*, comfortably in bed, will listen and return sweet thanks. It's quite a mistake to imagine that shouting is necessary in order to be heard through the Telephone. The more natural and conversational the tone the better. Clear enunciation is the most important requisite.

Telephones have not yet been ordered for churches, my dear, but I've no doubt they soon will be. I suggest that half a dozen churches now suffering under an exposition of sleep, unite on one preacher of power and eloquence. This preacher can speak from any one of the churches, or, if it suit him better, from his own study. The introduction of the Telephone will thus systematize public worship to a degree never before contemplated, and also promote economy, no mean consideration in these hard times. Choirs as well as preachers may be reduced. Five out of six can be dismissed, and organs can be sold for useless lumber. The quarrels of inharmonious musical committees can be brought to a peaceful conclusion, and the lion and the lamb unite in telephoning their chorus of thanksgiving. All that need be done in the churches where minister and choir are not personally present, will be to have

the sexton stir the fire and the vestrymen take up the collections. If members of any of these congregations desire to remain at home, they can tap the clergyman's wire and take their gospel with their matutinal coffee. In fact, they can have their cake and eat it too. Heretofore this has been considered impossible. Tyndall's lectures at the Royal Institution can be heard simultaneously throughout the provinces; so may concerts. As to operas and theatres where sight is almost as necessary as hearing, the Electroscope, combined with the Telephone, will render visits to London unnecessary. Of course there will be telephonic as well as gas and water meters, and every household will be taxed according to the amount of "Patti," "Our Boys," "Diplomacy," "Monday Pops," or "Royal Institution" consumed. Metropolitan newspapers will employ persons to read their articles to distant subscribers, so that the expense of printing and mailing copies will be done away with. And when it comes to the House of Commons, Ella, won't there be a revolution! Every anxious constituent in the provinces will have his parliamentary wire and private electroscope, so that he can not only hear but keep his eye on his special member, and Londoners who want to hear debates won't be obliged to beg for admission to a stifling atmosphere. This will be heavenly for us women, who at St. Stephen's are cooped in a bird cage. Cabinet ministers, instead of making the long journey to Balmoral, will have the honour of communicating telephonically with the Queen who may even open Parliament in this manner. Diplomatic correspondence will be abolished, ambassadors will talk a sign language to their governments, and navies will not dance into the Dardanelles for the pleasure of dancing out again, as flagships will have a coil of wire attached to the nearest telephonic station and so receive counter-orders in time to be spared the expense of harlequinades. All these modern conveniences are clothing life with new interest, and if somebody will only discover a way to induct the whole human race with common sense, being born will cease to be a bore.

Your telephonically attached friend,

PUSS.

Miss ELLA GRAHAM, Fifth Avenue, New York, U.S.A.

THE UNITED STATES' CENTENNIAL REPORT ON AWARDS.

PHILADELPHIA, 1876.

The United States Centennial Commission has examined the report of the judges and accepted the following reasons, and decreed an award in conformity therewith :—

PHILADELPHIA, *December* 26, 1876.

REPORT ON AWARDS.

Product—Graham Bell's electric Telephone and multiple Telegraph. Name and address of exhibitor — Alexander Graham Bell, Salem, Mass., U. S.

The undersigned, having examined the product herein described, respectfully recommends the same to the United Centennial Commission for award for the following reasons, viz. :—

The idea of an electric Telephone, or apparatus for transmitting sound to a distance by variations of electric current through a wire, has been for many years before the world, and has been realised in several ways, differing considerably in details, as the appliances at two points of the circuit for producing the variations of electric current and for deriving perceptible effects from them. An extension of this idea to some kind of electro-phonetic telegraphy was inevitable, even though no one had thought it might or could lead to practically useful results; but the idea of a multiple electro-phonetic telegraphy, transmitting simultaneously several different musical notes, and using intermissions of these (like intermissions of currents in so many separate wires), for the simultaneous and independent transmission of different messages by one wire, is a very fine invention of high scientific character, promising splendidly useful practical results.

This invention is claimed by Mr. Graham Bell, and he is entitled to full credit for it, even though, as I believe is the case, it has been also independently invented by others, both in England and America.

A very well worked-out realisation of it is given in Mr. Bell's apparatus, now exhibited. A great practical advantage of the electro-phonetic multiple telegraph over other methods

of multiple telegraphy through one wire is, that no adjustment is required for varying conditions of the line to render the non-interference among the different messages perfect. Another even more important practical advantage is, that it is indifferent between what points of the line and in which directions the different messages are being sent. The different messages can, in fact, be transmitted from any different points of the line, and each may be read at all other stations (whether stations from which others of the messages are being sent or not) with practically perfect non-interference. Another important advantage is, that earth-currents and lightning discharges will never disturb the signalling.

Mr. Graham Bell's apparatus includes an ingenious and effective instrument for automatically making and breaking an electric contact every time one of his telegraphic musical notes commences and ceases to sound. Thus his multiple telegraph may be made self-recording (after the Morse or Bain method), or may be worked forward by relay through greater lengths of line than imperfectness of the insulation allows to be worked in one circuit.

Mr. Bell showed me in action two of these electro-phonetic relays, recording quite independently the transmission of independent messages by two musical notes in one wire. In addition to his electro-phonetic multiple telegraph, Mr. Graham Bell exhibits apparatus, by which he has achieved a result of transcendant scientific interest—the transmission of spoken words by electric currents through a telegraph wire. To obtain this result, or even to make a first step toward it—the transmission of different qualities of sound, such as the vowel sounds—Mr. Bell perceived that he must produce a variation of strength of current in the telegraph wire as nearly as may be in exact proportion to the velocity of a particle of air moved by the sound; and he invented a method of doing so—a piece of iron attached to a membrane, and thus moved to and fro in the neighbourhood of an electro-magnet, which has proved perfectly successful. The battery and wire of this electro-magnet are in circuit with the telegraph wire and the wire of another electro-magnet at the

receiving station. This second electro-magnet has a solid bar of iron for core, which is connected at one end by a thick disc of iron to an iron tube surrounding the coil and bar. The free circular end of the tube constitutes one pole of the electro-magnet, and the adjacent free end of the bar-core the other. A thin circular iron disc, held pressed against the end of the tube by the electro-magnetic attraction, and free to vibrate through a very small space without touching the central pole, constitutes the sounder by which the electric effect is reconverted into sound. With my ear pressed against this disc, I heard it speak distinctly several sentences. First of simple monosyllables, "To be or not to be" (marvellously distinct); afterwards sentences from a newspaper, "S. S. Cox has arrived" (I failed to hear the "S. S. Cox," but the "has arrived," I heard with perfect distinctness). Then "City of New York," "Senator Morton," "The senate has passed a resolution to print one thousand extra copies," "The Americans of London have made arrangements to celebrate the 4th of July." I need scarcely say I was astonished and delighted; so were others, including some other judges of our group, who witnessed the experiments and verified with their own ears the electric transmission of speech. This, perhaps the greatest marvel hitherto achieved by the electric telegraph, has been obtained by appliances of quite a home-spun and rudimentary character. With somewhat more advanced plans, and more powerful apparatus, we may confidently expect that Mr. Bell will give us the means of making voice and spoken words audible through the electric wire to an ear hundreds of miles distant. WILLIAM THOMSON, *Judge.*

Approval of group judges:—

J. E. Hilgard, James C. Watson, H. K. Oliver, F. A. P. Barnard, J. Schudmayer, E. Levasseur, O. F. Kupka, Ed. Favre Perret, Chas. E. Emery, Joseph Henry.

A true copy of the record:—F. A. WALKER, *Chief of Bureau.*

Given by order of the United States Centennial Commission:— A. T. GOSHORN, *Director-general.*

J. R. HAWLEY, *President.*

J. L. CAMPBELL, *Secretary.*

SALEM RESOLUTIONS.

At a meeting of the Essex Institute, held at its rooms, Salem, Mass., U.S.A., February 19, 1877, the following resolutions introduced by Mr. A. C. Goodell, jun., were unanimously adopted:—

RESOLVED, That we tender our cordial thanks to Professor Alexander Graham Bell, and to his associate, Mr. Thomas Augustus Watson, of Salem, for the wonderful and profoundly interesting experiments so successfully performed by them at Lyceum Hall on the evening of the 12th instant; and to the Atlantic and Pacific Telegraph Company, who generously permitted the use of their wires between Salem and Boston; and to Miss Anastasia L. Molloy, who operated the telegraph on that evening.

RESOLVED, That the experiments we have witnessed satisfactorily demonstrate the feasibility of conveying articulate sounds by means of magneto-electricity; and we find that this method possesses advantages over the ordinary electric telegraph in the following particulars:

First, in the simplicity and cheapness of the mechanism employed.

Second, in dispensing entirely with batteries.

Third, in avoiding the necessity of employing skilled operators.

Fourth, in the apparently great motive force of the magneto-electric currents employed, and (according to the evidence exhibited by Professor Bell) in the fact that resistance is, by this means, so far overcome or avoided as to encourage the belief that, practically, no difficulty may be expected, from that source, in the longest circuits.

Fifth, in the rapidity of communication by the Telephone, and in the ease with which it insures accuracy by admitting of instantaneous vocal repetition from either end of a telephonic line.

RESOLVED, That the discovery that the vibrations of a conducting membrane or plate set in motion by the human voice can be so delicately and forcibly communicated to a corresponding membrane at the opposite end of an electric circuit, as to produce articulate sounds of exactly the same timbre, quality, pitch, and relative strength, appears to us one of the most marvellous discoveries of the age; and the practical embodiment of this discovery, in the Telephone, constitutes a most curious and remarkable invention; and we deem it especially noteworthy that these were not accidental, but the result of profound study of the science of acoustics, and a consequent inference that currents of electricity might be made to vary in intensity in the exact ratio that air varies in density when affected by sound.

RESOLVED, That we deem it a signal honour to have been privileged to witness the first public operation of this wonderful instrument, at a meeting, a report of the proceedings of which was sent abroad as *the first public message by the Telephone*.

RESOLVED, That we are gratified to learn that these experiments are to be repeated in Salem; and to them, as at once instructive and astonishing, we invite the attention of the public.

RESOLVED, That these resolutions be communicated to Professor Bell and to Mr. Watson by the Secretary; and offered to the press.

A true copy from the records.

GEORGE M. WHIPPLE,
Secretary.

A NEW INSTRUMENT.

"The account given by the *Boston Daily Globe* of the working of a new instrument or apparatus called the Telephone, makes it appear that sound may now be transmitted over long distances—up to a limit of something like twenty miles—as easily as sense, or at least information, has been transmitted for some time past. You may call out to a friend eighteen or twenty miles off with the certainty, provided you call to him through or along the Telephone, of making yourself heard and of enabling him even to distinguish and recog-

nise your voice. On the other hand, the Telephone cannot be used for addressing offensive or tiresome remarks to an unwilling hearer. Telephony, like scandal, requires two performers, one to talk, the other to listen. The Telephone, then, is an eminently peaceful invention, and incapable of being turned to any bad purpose except indeed that of lying. False news may, and no doubt will, from time to time be sent by Telephone as now by telegraph. But the risk of attempting to circulate deceptive intelligence will probably be somewhat increased by the fabricator's being required to call out his falsehoods at the moment of transmitting them; while correspondents, acting in good faith, will have new guarantees against fraud. One important purpose for which it is difficult, and often impossible, to use the electric telegraph is that of getting money transmitted. Under present arrangements it sometimes happens that a London banker receives a telegram from a customer abroad demanding by the next post a certain sum. Such a request cannot be complied with, since there is no possibility of verifying the applicant's signature. The banker's correspondent may, of course, be instructed by telegraph to pay to such a person a given amount; but the question of identity still remains an obstacle, and one which, in the case of timid, old-fashioned financiers, cannot be got over. A traveller, however, whose money has run out will, under the new Telephonic system, have merely to shout to his banker until the banker shouts to his correspondent to pay such a sum to such a person, who has just had the ear of the bank, and who is waiting at such a place. Telephony will, it is true, need a little development before such results as these can be obtained. The new invention is still in its infancy. But as perfect voice-messages can already be sent a distance of twenty miles, we may confidently look forward to the time when Telephony, as a means of rapid communication, will take its position side by side with telegraphy, to which it will doubtless for many uses be preferred. Many an epicure before starting for Paris would gladly order his dinner by word of mouth; and this, by means of a perfected Telephonic system, might easily be done. Even now

Telephonic despatches are sent along a line not much shorter than the distance from Dover to Calais; and these first experiments, we are told, are merely to be looked upon as establishing the practical success of 'an invention which seems destined to revolutionize electric telegraphy.'

"It seems that the first newspaper despatch 'sent by a human voice over the wires' was published in the journal which describes this remarkable achievement. The despatch consisted of a report, 110 lines long, of a lecture delivered at Salem, eighteen miles from Boston, by Mr. Graham Bell, explaining his 'Telephone, or apparatus for transmitting speech sounds and musical sounds of all kinds through the electric telegraph wires by means of the vibrations of the armature of a permanent magnet.' Sir William Thomson, at the Glasgow meeting of the British Association, last year, spoke in the highest term of the Telephone. But until the 13th of last month it had only been used for experiments—as for sending musical notes and songs, both notes and words—from Boston to Salem, and from Salem back to Boston. Some of these preliminary trials were astonishing enough; for the songs telephoned—if we may coin the word—from Boston were not only heard, but loudly applauded at Salem, so that a musical critic at Salem was able to send by Telephone, for publication at Boston, an account of the effect caused at Salem by the Boston music.

"In a commercial point of view, the success of the Telephone ought, indeed, to be very great. For what are called 'affairs of the heart' it will no doubt be greatly in request. A telegram, couched for the most part in a sort of nigger-English, for which a desire to keep within the regulation twenty words is the only excuse, is not the sort of communication that should pass between lovers. What would not a devoted admirer give for as many words as the object of his affection might be able to call out within a given time? What, above all, would he not be ready to pay for the privilege of hearing the very voice of the loved one? Private Telephones at so many hundreds a month might easily be let to persons about to marry; and the inexperienced, credulous as to the duration

of human passion, might even be tempted to take them by the year. In this latter case the use of the private Telephone would often revert to the company, or to the Government department by which Telephony may be taken in hand, long before the expiration of the term bargained for. Concert-givers and the enterprising class of musical agents will of course try to establish some sort of central establishment for the making of vocal and instrumental music, whence, as from a reservoir, it would be turned on, now in this, now in that direction, according to the requirements of subscribers. It is to be feared, however, that in connection with such a speculation as we have now in view, a certain amount of deception would be practised. A great many pretended connoisseurs recognise singers less by their voice than by their personal appearance; and the manager of the music-works or 'Central Harmonic Institute,' as it might be called, would not care to transmit the strains of an Adelina Patti at a cost of something like one shilling a note, when a much cheaper and coarser style of warbling would give equal satisfaction. What Herr Wagner calls 'absolute music' would become more absolute and more abstract than ever; and it would often no doubt be found, in the use of vocal music, that the singing lost much by being separated from the singer. Naturally the Telephone will be employed for military purposes; and a commander-in-chief, when he has once learned to use it, will be able to address the generals subordinate to him as freely and as effectively as though they were, in the ordinary sense of the words, within hail. Should the Telephone of one army fall into the power of the army opposing it, awkward results might no doubt ensue. The possibility of playing fatal practical jokes, by means of a captured Telephone, might, in a measure, be guarded against—as by entrusting all telephonic work to some one man who should be easily recognisable by a peculiar voice. It will be quite sufficient, however, if the Telephone should fulfil all that is expected of it in connection with the arts of peace. What the Telephone has already done is marvellous enough. It is something to have transmitted, verbally and vocally, by the Telephone a despatch 110 lines in

length; 'this wonder,' in the words of the *Boston Daily Globe*, 'being accomplished in a time not much longer than would be consumed in an ordinary conversation between two people in the same room,' and in such a manner that the person who listened to and wrote down the message, as it reached him, 'could easily recognise the voice at the other end.'"—*Daily News*, March 9th, 1877.

ELECTRIC TELEPHONY.

"On Wednesday, the 31st ult., the Society of Telegraph Engineers convened a special general meeting, for the purpose, as was gracefully put by its President, Professor Abel, C.B., F.R.S., in his introductory remarks, of according to Professor Graham Bell a welcome to England, and at the same time affording the members of the Society an opportunity of hearing from him the nature, history, and development of what may well be called one of the most interesting discoveries of the age.

"The lecture hall of the Institution was crowded to overflowing, the gathering being one of, if not the, largest known since its opening. Amongst those present were Professor Tyndall, F.R.S., Professor Stokes, M.A., F.R.S., Professor Huggins, F.R.S., Dr. Hugo Müller, Professor Hirst, F.R.S., Dr. Frankland, F.R.S., Professor Grote, Lieutenant-Colonel Elles, General Younghusband, C.B., F.R.S., Sir James Stokes, K.C.B., R.E., General Holland, Colonel Hay, R.A., Colonel Alderson, R.A., and many others of well-known reputation."—*Engineering*, November 9th, 1877.

REPRODUCTION OF ARTICULATE SPEECH.

"To what is aptly termed the *undulatory* system of currents of electricity, is due the consummation of the articulating Telephone. Like all other successful applications, now that success has attended its use, and now that its aptitude has been explained and demonstrated, we see that in the employ-

ment of this form of electric current alone it is possible to obtain the results which the long-continued researches of Professor Bell have led up to. In addressing the Society of Telegraph Engineers, he pointedly directed the attention of his audience to what he designated these primary varieties of telephonic currents, viz., intermittent, pulsatory, and undulatory. We know what an intermittent current is. It is the alternate flow and cessation, or the presence and absence of the current along a given wire. Pulsatory currents are described as sudden or instantaneous changes in the intensity of a continuous current, that is, a wire is traversed by a continuous current of an intensity of, say, 5. At an instant this intensity is increased to, say, 10. Graphically this is represented by a line of, say, one quarter of an inch in thickness, which represents the normal continuous current. At the point where the intensity is raised to 10, the thickness of the line becomes suddenly that of half an inch, and this continues so long as the increased intensity continues, and as soon as it is lowered to the normal power the line again suddenly drops to its normal thickness. Thus the sudden increase and decrease of these pulsatory currents would give us the figure of a line suddenly increased in thickness, according to the value of the increased intensity, at various distances governed by periods during which the increased current is in operation. From this the undulatory current differs very materially. If we cast a stone into still water, we observe the disturbance caused by it to result in a series of waves which are gradually reduced in volume till they are absorbed and die away. A tone uttered in air has a similar effect; it puts the air in its immediate vicinity in motion, creating a series of waves, the shape or formation of which is governed by the force, or volume of the sound, in the same manner as the volume of the ripple on the water is governed by the weight and force of the stone which disturbs it. These waves of water, or waves of air, are undulatory, and serve well to describe what is meant by the form of undulatory currents to which is due the production of the articulating Telephone.

"So far success has not attended the efforts of those who

have sought to employ the galvanic battery current for articulating purposes. Its varying power would necessitate frequent adjustment of the diaphragm in the neighbourhood of the magnet produced by it, whilst if employed for sending impulses direct to the distant point, its action would be that termed intermittent, and the result a series of vibrations of equal power, so that no approach to articulation would be possible. Each word uttered causes a series of vibrations in the air, but these vibrations are not abrupt, but of a modulated form, rising and falling, as has been represented like ripples on water. The only means which has yet been suggested for obtaining electrical action similar in character is that employed by Bell in his latest form, viz., currents produced by an armature placed in front of a permanent magnet. In the Telephone the diaphragm is the armature. Assume that in a certain position it is at zero. Move it an infinitesimal part nearer the magnet, and you alter the magnet's magnetic field; and if around the pole of the magnet is wound a coil of wire, a current will be set up in that wire for every fresh position assumed by the armature. The power of this current depends upon the rapidity of movement of the armature. If the movement is slow, a corresponding low current will be excited in the coil, and pass to the distant station; if it is rapid the current generated will be correspondingly of greater power and intensity. Hence the currents evolved are dependent upon the motion of the armature, whilst the motion of the armature is dependent upon the formation of the wave of air which presses upon it. Thus, then, the voice sets in motion the air in the neighbourhood of a Telephone; the motion thus set up disturbs the diaphragm, by which currents corresponding in intensity and duration to the wave impinging upon the diaphragm are set up, reproducing a corresponding action in the instrument at the distant station, which in its turn emits sound corresponding to the currents generated at the transmitting end of the wire.

"The invention carries with it the stamp of well-directed and meritorious research. It establishes a new era in telegraphy, and even as it stands, in its present embyro form, it has before

it a large and useful field. That it will supersede many of the present form of telegraph instruments, requiring in their most simple arrangement a certain amount of technical instruction, and hence the attendance of one or more qualified persons to carry on communication, is patent to all. That it will open up a means of communication which has practically been closed to many for want of that very technical labour is also clear, whilst in many other ways it will find a home. In fact, its field is that of the human voice. Wherever that is required to be employed between points sufficiently far apart to prevent absolute conversation by word of mouth alone, there will the Telephone come into requisition. Requiring no skilled labour, no technical education, easy to maintain, and cheap of construction, it may lay claim to a large share of public support.

"Independent of this, we may look for its employment in other useful spheres. It was but a few days since Sir William Thomson obtained some very useful and practical results from it in connexion with an anemometer placed in one of the shafts of a coal mine, by which the supply of air passing into the shaft was indicated above ground. It has been employed in numerous mines in Cornwall and other places for communication between portions of the underground workings and those above ground, and it is reported that in one case the miners were so impressed with its value to them that they resisted its removal.

"Another useful field for it is that of submarine exploration. With a wire woven into the air-tube of a diver's dress, and a simple provision for the instrument, the diver may make known to those above not only his own wants, but may report from his position the nature of things around him, and receive instructions from those directing his movements, to all intents and purposes, as though they were conversing in the same room.

"In military and naval evolutions it will prove of the utmost value. The staff officer will no longer need the services of an experienced clerk—no longer need he fear the divulgence of his general's plans, or of any portion of them. To him the communication can be made direct, by night or day, with or

without light; by the call of a bell his attendance is secured, and then all he has to do is to speak and listen. In naval tactics outlying boats may hold communication by a light cable with their commanding officer; whilst a network of telegraph may be spun round our coast from coastguard station to coastguard station, and proceedings be reported, from or to any point, at almost any moment. The coastguardsman on duty may strike his wire at any given spot on his beat, and call for aid, or report suspicious circumstances at will, and obtain aid or instructions without leaving his post. It is difficult to perceive a more useful application for it than this, and doubtless it is one which will commend itself to the proper authorities.

"So delicate is the instrument, that Professor Bell relates on one occasion, when trying some experiments with it, he was able to maintain communication with another person when standing upon a dry board, his foot touching merely a blade of grass, the current passing to earth through his body and by means of this single blade of grass. The amount of *resistance* through which it will work is practically illimitable. It is not too much to expect that it will be found of considerable service for testing the physical condition of the human frame, a point to which medical men are already giving attention. That it is as delicate as the stethoscope there can be little doubt, and the day may come when, by its aid, a medical man in the provinces may confer with his more learned brother in the metropolis, and jointly test the condition of an invalid whose state is such as to forbid removal."—*Engineering*, Nov. 16, 1877.

A GREAT INVENTION.

"A great change has come over the conditions of humanity. Suddenly and quietly the whole human race is brought within speaking and hearing distance. Scarcely anything was more desired or more impossible. Few, indeed, can fill a room of any size, or even make themselves well heard anywhere; and th ear itself is the weakest and most treacherous of our facul-

ties. The eye enjoyed an invidious superiority over the sister organ. Not to speak of its celestial achievements over other worlds, or of the kingdoms of the earth it could see in a moment of time, it encroached successfully on the domain of the ear, by beacons, and telegraphs, and all kinds of signals. Some of us may remember the line of telegraphs from the Admiralty to Portsmouth, throwing their arms wildly about ten minutes sometimes, while the bewildered clerks were turning over the leaves of their key or spelling a word. A storm or a fog, or nightfall, would interrupt the message, and there it slept till next day, no matter its importance or its urgency. The railway seemed to compensate for this, but with the railway came all the accidents and delays of personal agency. Then, about a generation ago, came the electric telegraph, too great a boon to be lightly spoken of, but even more divested of the charms that sweeten and assist communication than the old letter-writing. The writer might be known and loved in his letter, which could not help being characteristic; but the telegram was the dry bones of correspondence. Gushes, sighs, tears, sallies of wit, and traits of fondness do not stand the ordeal of twenty words for a shilling, and the frigid medium of unsympathetic clerks. All at once the telegram is found to be a barbarous makeshift, fit for business purposes, or mere messages, in which names, figures, places, and dates are all there is to be transmitted. For any higher or tenderer purpose the Telephone is to take its place. While we are talking about it, and hearing of its performances at scientific meetings, the Americans are bringing it rapidly into use. Already 500 houses in New York converse with one another; 3,000 Telephones are in use in the United States; they are used by companies and other large concerns wherever the works are some way from the office, in waterworks, pits, and mines. Friends on the opposite sides of a broad street converse as if in one room. The known tone and inflections of the speaker, a whisper, a cough, a sigh, a breath can be heard. The little incidents of human utterance which it takes a wakeful ear to detect, aided by the eye and by familiar acquaintance, are found to pass along miles of wire, many of them under the

earth or sea. Silent as the medium may be, and dead as it seems, the sound comes out true. A hundred miles of galvanic agency becomes only one imperceptible link between two human mechanisms.

"* * * * * * * * * The Telephone will prove a severe test of both our speaking and our listening powers. The household wire, it appears, need not be monopolized, or be at the mercy of one inefficient listener. Half-a-dozen Telephones, with their respective wires, can be attached to the same main wire, and as many ears applied. When it was found, now about fifty years ago, that tubes would convey the human voice sufficiently a hundred yards or more, it was immediately suggested that an honest and attentive body of Christians could stay at home on a rainy Sunday without being deprived of public ministrations. They might sit by their fireside, lend a willing ear to the end of a speaking tube, and hear the sermon delivered at the other end of the street. The voice, however, would not ramify to the desired extent. The electric current will ramify to at least a considerable extent. The very idea of such a use being made of it, improbable and even ridiculous as it is, suggests its convenience for many ordinary and secular purposes. The objection to a telegraphic system ramifying itself into every parish and every good house in the kingdom has hitherto been the fact that in very few households is there one who could read or work the instrument. That objection is now likely in time to be entirely removed. Everybody who has an ear can hear a Telephone, and everyone who has a tongue can speak into one. All that is wanted is a much-required improvement in our listening and speaking powers, with, of course, some considerable improvements in the Telephone. But the last point, however necessary, is simply a case of supply and demand. If wanted, the Telephone will be brought to the same pitch of perfection as telescopes, watches, sewing machines, photography, lucifer matches, locomotives, breechloaders, heavy ordnance, and many other things that within living recollection were either very clumsy affairs or not even yet invented. A time is coming when everybody,

we presume, will carry his own Telephone about with him. Wherever he goes he will be able to step into a telegraph office, apply his own wire to the public wire, and hold a private conversation with a wife, or a son, or a customer, or a political friend, at the end, without the intervention of a public servant. He will pay by the minute. The wire, it is stated, must be a quiet one, for it is apt to pick up stray sound. On the other hand, it is now announced that a remedy has been found for this, and that a wire thus encumbered can be cleared of strange utterances before it comes to the Telephone. Perhaps the use of underground wires, now on other accounts much insisted on, may be found a more effectual remedy.

"The discovery has come happily just at the time when there had arisen a dreary feeling that we had arrived at the end of original discoveries, and had nothing to do but work out our old ones. It is true we have been penetrating continents, sounding the deep sea, hunting matter down to molecules, finding perfume in filth, dyes in dirt, and food in refuse. It is also true that the annual catalogue of new facts in Science has been stated to amount to a thick, closely-printed volume. But these are not matters that concern everybody, at least directly. They do not revolutionize the world. What the Telephone promises is hardly short of this. There is no reason why a man should not hold conversation with a son at the Antipodes, distinguish his voice, hear his breathing, and if the instrument be applied as a stethoscope, hear his heart's throb. Next to seeing—nay, rather than seeing—what would parents give to hear the very voice, the familiar laugh, the favourite song, of the child long separated by a solid mass 8,000 miles in diameter? The telescope is only a prolongation of the eye, and the Telephone is only a second ear. For some time there has been a prophetic idea that a speech ought to be able to report itself. There is now no difficulty in the matter, except that the Telephone will be only too true, and will serve the orator and the public only too well. Will the Telephone be able to convey the singing of our birds to the less vocal tropical regions, the breaking of the surge, or any other of Nature's sweet or wild utterances? Will it bring to our metropolis the dreadful sounds of the bombardment or the battle-field? But what next? There is hardly anything conceivable that may not be hoped for, if not, indeed, expected. We have only to look back the length of an ordinary lifetime and consider how much the world has advanced in that period to form a fair estimate of what is in store for our successors. The world has not exhausted itself; mind has not done all its work; Nature teems with fresh wonders; time has more children yet to come. When shall we store and distribute the manifold bounties of Nature running to waste? When shall we counteract the uncertainty of the elements? When shall we penetrate the mystery of the winds? Shall we ever cover the whole earth with fertility and verdure? Shall we not only combat, but extirpate disease, as some diseases have, in fact, disappeared? To come down to the improvement of existing means, when shall we bring railway travelling to the perfection of speed, comfort, and safety? All these are mere mechanical problems. The greatest perfection is not so improbable as the railway itself was only fifty years ago. In none of these matters has mankind yet made so serious and persistent an endeavour as to be sure that the failure is not in itself, rather than in the work to be done. They seem impossible; so did the idea of the Telephone but the other day."—*The Times*, Nov. 19th, 1877.

A GOVERNMENT CONTRACT.

"Colonel W. H. Reynolds has just concluded a contract with the English Government, by which the Post Office Department has adopted the bell telephone as a part of its telegraphic system. In a recent telephonic experiment in connection with the cable, 21¾ miles long, between Dover and Calais, there was not the slightest failure during a period of two hours. Though three other wires were busy at the same time, every word was heard through the Telephone, and individual voices were distinguished. This important experiment was conducted by

Mr. J. Bourdeaux, of the Submarine Telegraph Company."—*The Times*, Nov. 23rd, 1877.

PROFESSOR BELL BEFORE THE SOCIETY OF ARTS.

NOVEMBER 30, 1877.

Telephony is receiving at the present time a great deal of attention from men of science all over the world, and it is my intention to-night to try and give you a short account of the means by which sound can be produced at a distance by electrical means. There are probably many here present who may recollect the early Telephonic experiments made in this country by the late Sir Charles Wheatstone. These experiments were repeated, and, perhaps, improved upon, in America, by Professor Henry, of the Smithsonian Institute, and others. I may direct your attention for a moment to one of these earlier Telephonic experiments in America. Two pianos were placed, one on each side of the road. A long deal rod was taken across the street, from the window of one house to that of the other, and the two ends of the rod were connected to the sounding-boards of the pianos. Under these circumstances, when a person played the piano in one house, the piano in the other house seemingly played by itself. The vibration of the sounding-board was communicated mechanically through the long wooden rod, and, at the other end of this wooden circuit, the sounding-board of the other piano was set into vibration, and the strings of the piano, which were in unison with those of the first one, were thrown sympathetically into action, and produced music.

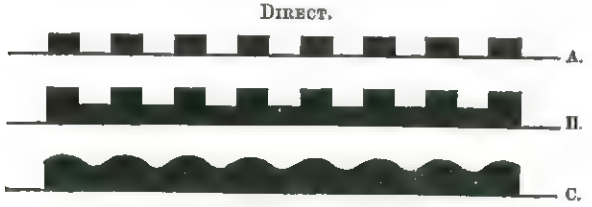
Another Telephonic experiment that I shall direct your attention to may be seen going on in the streets of London on almost any day. You may see persons in the streets exhibiting what is called the Telephone, consisting of a small membrane with a thread or a string attached to the end of it, and at a distance of one hundred yards or so there is another membrane. The two membranes are united by this thread or

string, and if you talk to one of these membranes it is thrown into vibration, and that vibration is mechanically communicated through the string to the other, and the sound is produced in the other membrane. But there is a difference between the early Telephonic experiments and those I wish to direct your attention to to-night. If you observe for a moment the *modus operandi* of the thread Telephone, you will see that there are two membranes which control one another's action through the vibration of a string. One of these membranes is forced to vibrate; it pulls the other by the string and releases it, and the two vibrate together. In this case, then, the sound is mechanically conducted along the string, but in electric telephony the sound is not communicated along the wire at all. It exists in the wire as a current of electricity, which produces, *de novò*, the vibration of a sound at the receiving end of a circuit.

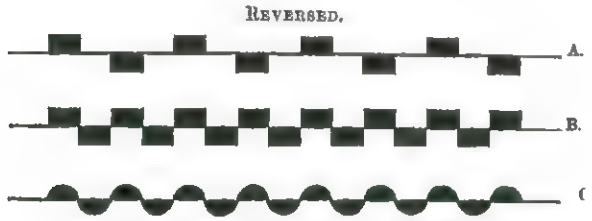
In examining the means by which sound can be electrically produced, I would direct your attention to several distinct species of what may be called Telephonic currents of electricity. For this purpose I will have the lights lowered, and a graphical representation of those currents will be thrown upon the screen. I distinguish three varieties of Telephonic currents, which I will designate intermittent, pulsatory, and undulatory. You have these three varieties shown in the three lines of the diagram, the upper one being the intermittent, the second, the pulsatory, and the third the undulatory. The horizontal line indicates the zero of the currents, and the dark lines are impulses of electricity. When these lines are above the zero they indicate positive impulses, when they are below, they indicate negative impulses of electricity. The vertical thickness of the electrical line from the zero indicates the intensity of the current at the point observed, so you will see that the characteristic of an intermittent current is the alternate presence or absence of electricity from the circuit. The characteristic of the pulsatory current is a pulsatory change in the intensity of the continuous current; but the undulatory current, to which your attention will be chiefly directed to-night, is a continuous

current of electricity, the intensity of which varies gradually, and in a manner proportional to the varying velocity of a particle of air.

The three radical varieties of Telephonic currents may be sub-divided into direct and reversed currents, or those in which the impulses are all of one kind, either positive or



A. Intermittent; B. Pulsatory; C. Undulatory.



A. Intermittent; B. Pulsatory; C. Undulatory.

negative, and those in which the impulses are reversed or are alternately positive and negative. You may still further discriminate varieties of direct currents accordingly as the impulses are all positive or negative. You may have a positive intermittent, or a negative or reversed intermittent current, so that you have nine varieties of Telephonic currents.

So far as I have been able to find, all previous experimenters in this branch of science have used intermittent or pulsatory currents in their attempts to produce sound, and I believe that I am the first to conceive of the employment of undulatory currents, whereby not only a noise or musical sound may be produced electrically, but sound of any kind—

the *timbre* of the sound as well as the pitch and force of it being preserved.

The question will naturally rise in your minds, how can these currents of electricity be produced? It will be my object to-night chiefly to speak of the undulatory current and the means of producing it; but I may here state that I have not yet been able to produce a true undulatory current, and the methods which I shall show you to-night are only approximately undulatory. I shall pause, then, first, to consider one of the means by which intermittent currents of electricity can be produced, and I will have thrown on the screen an illustration of an apparatus devised by Helmholtz, consisting of a tuning-fork placed between the poles of an electro-magnet; a platinum wire attached to one of the prongs of the tuning-fork dips into a cup of mercury, thus completing a voltaic circuit. So long as the platinum wire touches the mercury a current of electricity traverses the circuit, passes through the fork, and then through the electro-magnet, and so to the other pole of the battery. Under the circumstances, so long as the circuit is closed, the soft iron core of the electro-magnet attracts the prongs of the tuning-fork, and the result is that the prongs are separated: the result of that is that the platinum wire is lifted out of the mercury; the moment it leaves the mercury the circuit is broken, the current of electricity ceases, the magnetism of the magnet ceases, the attraction of the iron core ceases, and the fork springs back by its own elasticity. Hence, the moment the platinum wire touches the mercury again, the prongs are again attracted apart, and are again released, so that the result is that the fork is thrown into continuous vibration, and at every vibration it makes and breaks the voltaic circuit, thus causing an intermittent current of electricity.

The means by which a musical tone can be produced by means of this intermittent current of electricity will be shown in the next illustration, which is a fork, also arranged by Helmholtz, by which one tuning-fork is made to communicate its vibrations to another fork of the same pitch, by means of an electrical current conveyed through a wire. By the use of a

resonator placed in front of the second fork, you can reinforce the sound and make it louder or softer, by opening or closing the orifice of the resonator. An arrangement by Helmholtz will next be shown, by means of which a number of tuning-forks are set in simultaneous vibration by the action of one fork dipping into mercury, so that you have a large number of musical tones produced simultaneously from these forks. Helmholtz made a very remarkable experiment with these forks, varying their loudness by resonators, so as to combine the musical tones in different proportions, and the result was that he was enabled to copy the *timbre* of sound. He was able to produce by this external reinforcement of the forks the effect of certain vowel sounds, for instance, *oo* or *ah*, different forks being reinforced in different degrees.

I shall now show you the diagram of an apparatus for the production of an approximately undulatory current of electricity. I have here a harp of steel rods attached to the poles of a powerful permanent magnet, and the same arrangement is repeated at the other end of the circuit. Between the rods of this harp we have at each end an electro-magnet. We know that when we move a magnet in the neighbourhood of an electro-magnet, we induce in the coils of the electro-magnet a current of electricity, the intensity of which is proportional to the velocity of the motion of the magnet; and not only so, but the kind of current, or its polarity, depends on the direction of the motion of the magnet. If I move my magnet downwards, I produce, say, positive electricity; and then, on the other hand, if I move it upwards, I produce negative electricity, so that it is evident to you that, when we vibrate a permanent magnet in front of an electro-magnet, we produce a reversed current in the electro-magnet, and the intensity of the current is proportional to the velocity of the moving body. Hence, we have our undulatory current of electricity. This undulatory current may be utilised to produce a sound at the distant end of the current in the following way. Let us suppose, for instance, that we have these two harps, that we pluck with the finger one of these rods; it vibrates, and produces a certain musical tone. In vibrating, we have an undulatory

current of electricity produced, which traverses the circuit and passes round the coil of the distant electro-magnet. What is the result there? The result is, that this electro-magnet alternately attracts and repels the rods about it, the positive current attracting, and the negative current repelling them; so that when an undulatory current traverses it we have a succession of positive and negative impulses, and the soft iron core alternately attracts and repels the rods above it, and the rod which is in unison with the one agitated at the other end will be thrown into vibration. So that, if you were to play a tune upon this harp, the corresponding rods at the other end would be thrown into vibration, and the tune would be reproduced. But you will observe that the vibration of this harp is not communicated through the wire mechanically; as in the case of the piano experiment that I have referred to; but the vibration of the rod creates or induces a current of electricity, which current traverses the wire—of course, with the speed of electricity — and will go to any distance, so that instead of having one of these pianos on each side of the road you may have them hundreds of miles apart, and a telegraph wire between them, and play one piano, and the other will appear to play by itself.

If I were to show you Helmholtz's apparatus for the artificial production of vowel sounds, you would see that certain *timbres* of sound were produced by causing the tuning-forks to sound simultaneously, with different relations of force. By the arrangement just described we can cause certain of the rods of the harp to vibrate with certain relations of force. For instance, if I pluck one of these rods very forcibly, the current of electricity produced will be very intense, because the intensity of the current depends on the velocity of the moving body. Hence, when you vary the amplitude of the vibration you vary the intensity of the current. Accordingly, if you pluck one of the rods very forcibly, you will have an intense current produced, and the corresponding rods will be thrown into vibration forcibly, but if you pluck the rod gently a feeble current will be produced, and the rod at the other end is thrown into vibration feebly. If you sound a number of

these rods simultaneously, with different relations of force, you will find the rods of the corresponding harp thrown into vibration, with corresponding relations of force. So that if you can produce a vowel sound by vibrating simultaneously a number of these rods, you can transmit a current of electricity which will produce the same sound from the harp at the other end of the wire. If you sing into a piano, keeping the pedal down so as to leave the strings free to vibrate, you will find that not only is the pitch of your voice echoed back to you from the piano, but also an approximation to the quality of the vowel. If you sing *ah* or *oo* you will find an approximation to these sounds produced from the piano. And the theory shows that if the piano had a very much larger number of strings to the octave, we should have not an approximation but a *fac-simile* of the vowel sound. When you sing the sound into the piano, certain of the strings are set in vibration sympathetically by the voice, with different degrees of amplitude, and the result is that you have these strings going on vibrating after the voice has ceased, with the result that the force and the vowel sound is echoed back.

The next illustration shows you my first form of articulating Telephone. If you had a large number of steel rods to the octave, and were to speak in the neighbourhood of such a harp, the rods would be thrown into vibration with different degrees of amplitude, producing currents of electricity, and would throw into vibration the rods at the other end with the same relative amplitude, and the *timbre* of the voice would be reproduced.

However, there are still simpler methods of producing undulatory currents of electricity, and the best way of showing you the method of producing the required current will be to trace the various steps by which the present Telephone has grown from the apparatus I have just shown you.

You will observe the effect produced upon the line of wire by the vibration of two of the rods of the harp I have spoken of; and in the next illustration I show you the effect of vibrating a number of permanent magnets simultaneously over an electro-magnet.

[Professor Bell here described in detail, and showed by a diagram, the result of the combined vibrations of two notes forming a major chord, the ratios of the vibration being as five to four, and the resultant curve being the algebraic sum of the two.]

The effect is, when you vibrate more than one of these rods simultaneously, to change the shape of the electrical undulation, and a similar effect is produced when a battery is included in the circuit. In this case the battery current is thrown into waves by the action of the permanent magnets. Hence, you will see that the resultant effect on the current of a number of musical tones is to produce a vibration which corresponds in every degree to the moving velocity of the air. Suppose, for instance, you vibrate two rods in the harp, you have two musical notes produced; but of course if you pay attention to a particle of air, it is impossible that any particle of air can vibrate in two directions at the same time; it follows the resultant form of vibration. One curve would show the vibration of a particle of air for one musical tone, the next one for another, and the third the resulting motion of a particle of air when both musical tones are sounded simultaneously. You have, by this apparatus, the resultant effect produced by a current of electricity, but the same resultant effect could be produced in the air.

In order to show you the resultant vibration of the air from different sounds, I shall put another illustration on the screen. This shows, not the variation of intensity of a current of electricity, but the variation of the velocity of a moving particle of air; and the curves now on the screen represent graphically the movements of air for certain vowel sounds. They have not been theoretically calculated, but are actually tracings produced by the voice itself. Of course, we all know the instrument entitled the phonautograph, and these curves were drawn by an improved form of phonautograph. There was a cone into which you spoke, which condensed the air from your voice; at the small end of the cone, you had a stretched membrane, which vibrated when a sound was produced, and, in the course of its vibration, it controlled the

movement of a long style of wood, about 1 ft. in length, and these curves were drawn by the style upon a surface of smoked glass, which was dragged rapidly along. I myself uttered the vowels that are here shown, viz., *e*, *ay*, *eh*, *ah*, *aah*; these vowels were sung at the same pitch and with the same force, but you will observe that each is characterised by a shape of vibration of its own. In fact, when you come to examine the motion of a particle of air, there can be no doubt that every sound is characterised by a particular motion. It struck me that if instead of using that complicated harp, and vibrating a number of rods tuned to different pitches, and thus creating on the line of wire a resultant effect, we were at once to vibrate a piece of iron—to give to that piece of iron not the vibration of a musical tone, but to give it the resultant vibration of a vowel sound, we could have an undulatory current produced, directly, not indirectly, which would correspond to the motion of the air in the production of a sound. The difficulty was, however, how to vibrate a piece of iron in the way required. The following apparatus gave me the clue to the solution of the problem in the attempt to improve the phonautograph :—I attempted to construct one modelled as nearly as possible on the mechanism of the human ear, but upon going to a friend in Boston, Dr. Clarence J. Blake, an aurist, he suggested the novel idea of using the human ear itself as a phonautograph, and this apparatus we constructed together. It is a human ear. The interior mechanism is exposed, and to a part of it is attached a long style of hay. Upon moistening the membrane and the little bones with a mixture of glycerine and water, the mobility of the parts was restored, and on speaking into the external artificial ear, a vibration was observed, and after many experiments we were able to obtain tracings of the vibration on a sheet of smoked glass drawn rapidly along. Many of those were very beautiful, and I am sorry I have not any of them here to-night to show you, but as it is foreign to our subject, it is, perhaps, as well. I would merely direct your attention to the apparatus itself, as it gave me the clue to the present form of Telephone. What I wanted was an apparatus that

should be able to move a piece of iron in the way that a particle of air is moved, by the voice. It struck me in the course of these experiments that there was great disproportion between the tissue of the membranes and the bones that were moved by the membranes, and that if such a thin and delicate membrane could vibrate a mass of bone, so disproportionate in size and weight, perhaps a membrane might be able to vibrate a piece of iron in the way required. I therefore constructed a second form of articulating Telephone, founded on the first apparatus by which I was, at the time of these experiments, producing undulatory electricity for the purpose of producing musical tones. It was similar to the rods shown you before, except that instead of being attached to a permanent magnet it was attached to one pole of an electro-magnet, and magnetised by means of a battery current. A current being passed through the coils of the magnet this piece of iron became magnetic, and a rod attached to one pole would of course become magnetic also, as if attached to a permanent magnet, so that, on vibrating this rod in any way whatever, the battery current was put in operation, and the corresponding rod at the other end thrown into vibration. I therefore took this apparatus, and instead of clamping the rod firmly, it was attached loosely to one extremity of the magnet, and the other end was attached to a stretched membrane of goldbeater's skin; and the same at the other end. The idea was that on speaking to this membrane, it would be thrown into vibration, and cause the vibration of the piece of iron—that in fact the iron would follow the motion of the membrane, that is, of the particles of air; it would, therefore, induce an undulatory current of electricity, the intensity of which would vary with the motion, and at the other end the intensity of the magnetic attraction would vary in a similar way; so that the piece of iron at the other end, being attracted and repelled in a varying manner, would be thrown into vibration, copying the motion of the first, and it in turn would cause the motion of a second stretched membrane, which would move the air in the neighbourhood, and we should thus have a sound produced. The idea was, that not only would the two pieces of

iron vibrate together, but the form of the vibration would be the same, so that on speaking in the neighbourhood of one membrane we should have a fac-simile of the sound produced at the other end. The apparatus was constructed, but the results were rather unsatisfactory. My friend, Mr. Thomas Watson, who assisted me, however, asserted that he could hear a very faint sound proceed from the second membrane when I spoke in the neighbourhood of the first. Encouraged by this fact, I varied the apparatus in a number of ways, and eventually produced three distinct forms of apparatus, which were exhibited at the Centennial Exhibition. I came to the conclusion that this piece of iron was probably rather too heavy to be set in vibration by the membrane, and I therefore made it as light as possible; in fact, I took a piece of steel spring, only about the size of the pole of the electro-magnet itself, and glued it to the centre of the membrane. Upon constructing two of these instruments, there was no mistake at all that articulate speech was produced; but it was of a very imperfect nature. When a person spoke or sung into one of these instruments, you could distinctly hear the tones of the speaker's voice at the other end, and could recognise that there was articulation there, and when you knew the sentence that was uttered, you could recognise the articulation, and it seemed strange that you could not understand what it was at first. The vowel sounds seemed to be copied very fairly, but the consonant sounds were entirely alike.

Another form of apparatus constructed at this time for producing an undulatory current, I have a photograph of, but it is a different size to the others, and cannot be thrown on the screen. It consists of one portion of the apparatus turned horizontally; attached to the membrane of gold-beater's skin is a little bit of cork carrying a platinum wire, which dips into a cup containing water. We know that water offers an enormous resistance to the passage of an electrical current. If you place two wires in water, separated by a slight distance, the resistance offered by the water is very great; but if you bring the wires nearer together, the resistance becomes less and less, so that the current of electricity becomes stronger

and stronger, and when the two wires can be put in actual contact the resistance of the water may be ignored altogether. Hence you can see that by vibrating two wires to and fro in a liquid of high resistance included in the circuit, the battery current can be thrown into waves, and the resulting current may be considered as approximately undulatory; and with this form of apparatus I was able to produce articulate sounds. But it was no improvement on the first. I produced the effect of articulate speech by vibrating the conducting wire in this way in pure water, in water acidulated with dilute sulphuric and other acids, in salt and water, and in a number of other liquids. I also produced the same effect by vibrating a solid of high resistance in a liquid of low resistance. Instead of a platinum wire dipping into water, I had plumbago dipping into mercury. The plumbago offered a good deal of resistance to the passage of the current, but as it dipped into the mercury it offered less and less, and by having a very small piece of plumbago vibrating in the mercury, the current was varied in a manner approximately undulatory, and articulate effects were produced when this apparatus was used as a receiving instrument.

I found, however, that the best means I could devise for producing an undulatory current was the apparatus I will now show you, but it did not serve well as a receiving instrument, and I was therefore led, after many experiments, to construct another form of receiving instrument, keeping this for transmission.

This [a diagram of the instrument was thrown on the screen] is one of the forms shown in the Centennial Exhibition. On speaking into this, and listening to the other, articulate sounds were heard very distinctly.

The next illustration shows the form of receiving instrument to which I was led. It consists of a hollow box of iron, with the electro-magnet inside, and a thin diaphragm of iron laid on the top as a lid. Upon resting the ear closely against this diaphragm, articulate sounds were very clearly perceived when the first instrument, as shown at Philadelphia, was used as a transmitting instrument. I was so convinced, from these

experiments, that the inductive method of producing an undulatory current was the best method, that I determined to vary the construction of the first form of apparatus, and I gradually varied the size and power of my magnet, and the size and thickness of the iron spring attached to the membrane, and the size of the coil. I found, as I diminished the size of the coil, the resulting sound at the other end became very much louder; in fact, I found there was no advantage in using a coil that extended beyond the centre of the magnet. Indeed, there is very little difference, in effect, between a coil of that size, and a mere flat spiral placed once round the magnet. The important point is to cover the pole of the magnet. Every succeeding turn adds resistance, without increasing materially the loudness of sound. I varied the power and size of the magnet by varying the power and size of the voltaic battery employed to magnetise it, and found that very little effect was produced by diminishing the power of the battery. In fact, the effect of articulate speech was produced from the receiving instrument when the battery was entirely removed from the circuit. In that case the only source of power would be the residual magnetism of the iron bar, and that showed that the only use of the battery could be to magnetise the iron bar; so, in subsequent forms, I dispensed entirely with the voltaic battery, and used a straight bar of iron magnetised steel. Increasing the size of the iron plate attached to the membrane, a very large increase in the loudness of the sound resulted, until finally I had a plate of iron almost as large as the membrane itself. By this, dispensing with the membrane altogether, perfect articulation was, for the first time, obtained, and in this form, which differs very immaterially from the present form, you have a plate of iron vibrated by the voice, in front of a permanent magnet with a coil of wire around it.

On varying the size and thickness of the permanent magnet, it is found that wonderfully little difference is produced by magnets of very different force, and on varying the size, diameter, and thickness of the iron plate, wonderfully little difference is produced. The chief difference is a peculiar effect on the quality of the voice. I have produced distinct articulations from iron plates all the way from 1 in. in diameter up to 2 ft., and from $\frac{1}{16}$ in. to $\frac{3}{8}$ in. in thickness. In fact, if you take an ordinary Morse sounder, and use that as a receiving instrument, using a battery current to magnetise it, if you place the armature of the Morse sounder close against your ear, articulate sounds are produced from it. This shows very distinctly that the effect is probably molecular rather than anything else, and the vibration of the plate as a whole mars the effect. One of my best forms of instrument was constructed on this model, but I had the cavity completely filled with a pad, to prevent the vibration of the plate as a whole, and it articulated beautifully. When the pad was taken out, a peculiar effect accompanied the articulation—a drum-like effect, due probably to the vibration of the plate as a whole. In fact, I can describe very distinctly the effect produced by varying the size of the plate. Suppose we keep the plate of uniform thickness, and vary the diameter, commencing with a small plate, we have articulation perfectly distinct, but it sounds as if you were speaking with a cold in your head; a purely nasal quality accompanies the sound. Now, keep the thickness uniform, but enlarge the diameter, and as you do so the nasal effect wears away, until, with a certain diameter, you obtain a very good quality of voice. Keep on enlarging it, and a coarse, hollow, drum-like effect is produced, and when you have it very large it sounds as if you had your head inside a barrel—a kind of reverberating sound. So keeping the diameter of the plate uniform and varying the thickness, commencing with a very thin plate, you will have the same drum-like effect. Now, as you gradually thicken the plate, you have the effect disappearing. Then you get articulation, and as you go on increasing the thickness you have that peculiar nasal quality produced, so that it is probable that the fundamental pitch of the plate itself has a great deal to do with the agreeableness or disagreeableness of the electrical articulation, but the size or thickness does not seem to impair the distinctness of the articulation itself. You see there is a peculiar form of mouthpiece for concentrating the air on the plate. I made one experiment of rather a striking nature,

viz., I omitted entirely the cavity in the mouthpiece. The iron plate was glued solidly at every point against a block of wood, and I talked against the surface of the block, so that there was an inch of wood between my mouth and the iron plate. Yet I was able to carry on a conversation with a man three miles away. I will now show you the last form of apparatus, and it differs very little from the previous one. [Professor Bell here explained in detail, by the aid of the illustrations, the form of instrument.]

The effect of reversing an undulatory current is to strengthen and weaken the magnet, and the result is that the plate is attracted in a varying manner, and the plate at the receiving end vibrates in a similar manner to the one at the transmitting end, and so a similar sound is produced. You, therefore, have the voice of the speaker converted into electricity here, and at the other end of the circuit you have the current of electricity re-converted into sound. No voltaic battery is used in this form—nothing but the magnet itself. I may here state one defect of this current. I have stated that I have not yet discovered the means of producing a strictly undulatory current. It frequently happens that, for practical purposes, the current is sufficiently undulatory to produce, at the other end, the effect of articulate speech, but the current produced in the coil is not strictly proportional to the velocity of the motion of the plate, as was pointed out to me by my friend Professor Cross, of the Institute of Technology at Boston, for there is another effect produced depending on the proximity of the iron plate to the pole of the magnet. If it be moved with a certain velocity, and the plate is very near the pole of the magnet, the effect produced would be very much greater than if it were farther away; so that you have the approximation or the separation of the two affecting the result. In fact, when the plate vibrates towards the pole, the current produced is too strong, and when it goes from the pole of the magnet it is too weak, so that the effect is not strictly an undulatory current. If the amplitude of the vibration of the plate is very great the defect is magnified, but if it is lessened the effect more nearly approximates to the undulatory character. Hence the curious effect, that soft speaking is much more distinct than loud speaking. If you shout or roar into the Telephone, you have the sound produced at the other end very loudly; but a discriminating ear will recognise that the articulation is not so distinct as when you speak more softly into the instrument. However, theory shows one way in which the defect can be remedied. Suppose we have alternate impulses going along the wire, and that, when the plate comes towards the magnet, we have a positive current produced, and when it goes away, a negative current. The coil may be so arranged that, when the positive current traverses it, the magnet will be strengthened, and it will then attract the plate with greater force; and thus, when the first plate approaches the magnet, the other will do the same, and thus the defect will be magnified. But we may also arrange the coil so that, when the first plate approaches the magnet, the other will recede from it, and thus the effect I have spoken of will be neutralised.

This leads me to a very curious point in the use of the Telephone, viz.: that you can control the phase of a vibration by specially arranging the coil. You can take two Telephones and arrange them so that, while some person makes a musical tone into the receiving instrument, the phases of vibration of the plates shall be identical or opposed. Sir William Thomson, a few days ago, made an experiment of this kind with me in Glasgow, and we found that the Telephone is a beautiful instrument for illustrating the interference of sound. If you arrange the instruments so that you have the phase of vibration the same, and then place your ear to the instrument, you can perceive the sound approximately doubled in intensity; but arrange them so that the phases are opposite, and there is a "dead spot"—silence is produced at one point. I never heard interference of sound so beautifully illustrated as in that experiment, and there is no doubt that many uses can be made of the instrument in acoustics, from the fact of our being able to control precisely the relative phases of two vibrating bodies. The experiments made with this Telephone a few days ago by Sir W. Thomson have demonstrated the

fact of an interference in the perception of sound. For instance, take two instruments, one vibrating in a certain phase, and the other in a phase nearly, but not quite, the same. Place one to one ear, you perceive the sound on that ear alone. Place the other to the other ear, and you perceive it on that ear alone. Place them to both ears at once, and you can arrange the phases of vibration so as to make both tympanic membranes act at the same time, or vibrate in a different manner; and there is a curious difference in the perception of the sound. It cannot be described, but it is something of this kind. You place the instrument to each ear in that way; where the phases are identical, you have a single sound, and you may localise the sound say on the surface of the two ears, but when the phases of the vibrating plates are reversed, the locality of the perception seems to change, and it seems as if you heard the sound at the back of the head, instead of at the surface of the ear. Moreover, if you take two distinct circuits, and have one Telephone on one circuit, and one on the other, and have a musical tone produced from one Telephone, which is almost, but not quite, in unison with that produced from the other, you have beats.

We know that if two organ-pipes, for instance, were vibrating in this room, the pitches of which were adjusted in that way, we should be cognisant of beats, illustrating the interference of sounds of that sort. Sir William Thomson writes me that he has shown that the same effect is produced in the sensation of sound, for, placing one plate to one ear and the other plate to the other ear, so that each ear perceived only one sound, the same effect of beats was produced, showing very conclusively the interference in the sensation of sound itself.

The next illustration shows the way in which the Telephone can be employed for the actual purpose of conversing at a distance. It is preferable to employ for this purpose two Telephones, one in front of the mouth, and the other at the ear, for it has been found that when one Telephone alone is employed, it constantly happens that persons separated by miles of distance speak at the same time or listen at the same time, and by placing one Telephone to the ear and

the other to the mouth, conversation at once becomes practicable.

Of course the question will naturally arise, how far can it be possible to use the instruments? That as yet we do not know. The limit has not been found. In laboratory experiments no difficulty has been found in using an apparatus of this construction through a circuit equivalent to 6,000 miles. In this instrument we have a powerful compound permanent magnet. The longest actual wire I have been able to experiment upon has been 258 miles in length, and no difficulty was experienced so long as the other parallel wires were not in operation. The instrument is wonderfully sensitive to inductive influences, and when you use a wire upon the poles with other wires you have the benefit of the other messages that are passing along the other wires on the Telephone. However, means have been discovered very recently by which the inductive influence of other wires can be overcome and neutralised, so that I hope we may have the instrument in use upon circuits of all lengths. I do not know that there are any other points that I should like to mention to you to-night, excepting a new application that is shown here to a diving apparatus. Inside the diver's helmet you place a Telephone of convenient structure, and in the place of using a separate telegraph wire, we use the wire that is coiled up inside the breathing pipe. In every breathing pipe of course there must be a coil of wire, in order to withstand the pressure of the water, and that wire we find can be used for the purposes of the Telephone, so that the wire inside this pipe is connected with the Telephone inside the diver's helmet, and the earth connection is simply made by attaching the other wire to the helmet itself, which is in contact, outside, with the salt water. I had the pleasure of conversing with a diver yesterday, with perfect success, at Messrs. Siebe and Gorman's, in a tank. He heard every word I said, and I was able to understand every word he said; and when I told him to come up, by word of mouth, he obeyed me. I do not know that there are any other points of interest to you, but I shall be very happy to attempt to answer any questions that may be put.

DISCUSSION.

Mr. S. FORD asked what was the difference between this form of Telephone and that shown at the Queen's Theatre some time ago by Mr. Varley; also whether the time was increased before the sound was received according to the length of the wire.

Professor A. G. BELL said the Telephone of Mr. Varley was similar to his only in name. There was no similarity whatever between the ingenious apparatus devised by that gentleman for producing musical tones, by the action of intermittent currents of electricity and pulsatory currents, and his own apparatus for producing the *timbre* of a sound by utilising undulatory currents of electricity. There had been numbers of Telephones brought before the notice of the public, but all previous Telephones had consisted merely of methods for producing musical tones, and he believed his was the first which had been constructed, in which the *timbre* of the sound was copied. In reference to the other point, he might state that no difference had been observed in the time required for transmitting sound. In conversing with his friend, Mr. Watson, when he was in New York and the latter in Boston, he put questions to him through the Telephone, and instantly the answer came back as though they were in the same room, instead of being separated by 258 miles of actual distance. The speed was the speed of electricity, not the speed of mechanical vibration.

Mr. J. SCOTT RUSSELL, F.R.S., said he did not rise to put any questions, but to express what he felt sure was the feeling of many present of extreme gratitude to the lecturer. There was probably no one who felt that debt more deeply than he did. The paper had taught some doctrines wonderfully wider and grander than even the interesting doctrines of the Telephone, and taught them that the electric wave which went through the conducting wire was a wave, as was well said, not of mechanical force, but a wave of ethereal force, meaning the impalpable atmosphere through which the waves or electric force were transmitted at present by electric cables from

England to America, and this same electric, atomic, or ethereal force was propagated at a uniform velocity, whatever was its nature, through a given wire or channel. But if, instead of this electric wire, he were to take a great channel of water 100 miles long, and then to take, instead of the plate of iron, or drum, a large plate of iron moved by a mechanical force—much like that which moved the drum of the ear—the force which he put into one end of the water channel would carry to the end of the 100 miles an exact copy and measure of the force which he had put into it at this end. This existed in air, in water, in electricity, and in ether, and it was one and the same law which governed all. The same propagation through the same ether brought the rays of the sun's light from the sun to the earth, and the same carrier wave brought from the other side of the globe, from the oceans there, which were disturbed by the attraction of the sun and moon, those waves all round the coasts which were called tides. All these phenomena, from the tides and the wind to the rays of light and to the sounds of the Telephone, were the motion of one simple phenomenon, the carrier wave, the wave of translation. In conclusion, he begged to move a hearty vote of thanks to Professor Bell.

The CHAIRMAN said that at this late hour he would not detain the meeting with more than a very few words. It was evident to all that they were witnessing the beginning of an invention destined to produce enormous benefits in our social condition. In one sense it was an infant invention, but in another it was evident that it had made great steps towards maturity. It was a principle in the progress of inventions that the first attempts at producing any great result were far more complicated than the form ultimately adopted; the progress of modern invention essentially consisted of simplification. This had been illustrated in this lecture, the first instrument described being extremely complicated. Professor Bell was aware that he had a complicated effect to produce, and could not suppose at first that it was producible by very simple means; but having gone through the process of simplification to a great extent, there was no doubt the invention

had gone a long way towards maturity. It seemed as if the only thing left to be done was to increase the intensity of the effects, so that a whole room should be able to listen to the sounds produced, then, for instance, those who could not get in to-night might have assembled in a room over the way and heard the lecture. . If they thought of the beginnings of the discoveries on which electric telegraphy depended in other branches, such as the discovery of the motion of the needle, or Faraday's discovery of induced currents, it seemed extremely probable that the exertions of Professor Bell and others who might take up the work would result in increasing very greatly the effects which they had perceived to-night, even if there was not much room left for further simplification in the means. Mr. Scott Russell had already expressed the general feeling of thanks to Professor Bell, and he would only put the resolution. The resolution was carried unanimously.

A NEW VOICE.

"The nineteenth century seems destined to throw more light on the marvels of electricity than all preceding ages. The latest discovery is that of Alexander Graham Bell, a Scotchman by birth, and an American citizen by adoption, who has literally succeeded in making iron talk. The telephone is a singularly simple electric apparatus, through the medium of which the human voice or the tone of an instrument generates the electric current, and reproduces itself in all its characteristics of pitch, intensity, and quality hundreds of miles away. Mr. Bell's instrument both sends and receives sounds. It consists of an ordinary electro-magnet, mounted before a membrane of steel in a sounding box, and connected with a telegraph wire. It can be used in connection with a battery, transmitting music from a telephonic organ by means of small steel points touching the reeds of the instrument, and each communicating with a wire. Thus are produced musical tones and chords at the receiving end of the wire used. Its distinguishing achievement, however, requires no battery. To convey the tones of the human voice, however, the instrument is disconnected with the battery, and the circuit is made through the earth. . . . .

"Owing to the extreme sensitiveness of the telephone it has been difficult at times to hear conversation when adjoining wires were at work, but this serious drawback can be overcome, and the latest experiments by cable between Calais and Dover make no such charge against the telephone, even when its wire was unprotected. The cable is 21¾ miles long, the copper resistance being over 236 B.A. units; and during two hours of conversation in English and French there was not the slightest failure. The operator at the telephone could distinctly hear the signals by the three other cable wires, and when only one of the three wires was working he could decipher the Morse signals and read a message passing from Glasgow to Paris. Yet when all three wires were busy the telephone wire was easily and clearly distinguishable above the click of the signals. Voices were recognised on both sides of the Channel, and a woman's voice was known at once. In experimenting on a line three quarters of a mile long, this same operator arranged a feeble-toned musical box under the receiver of an air pump, the top of the receiver being open. Upon this opening was placed the telephone, and every note came out clearly at the other end of the wire. While testing the telephone through the cable the same means were not obtainable, but by simply holding the instrument to the mouth of the musical box the notes were audible across the Channel—not so perfectly, however, as on the shorter line. One young lady burst out laughing the moment she put the telephone to her ear, exclaiming with delight, 'Some one is whistling, Tommy, make room for your Uncle!' Breathing could not be heard in consequence of the continued pecking caused by induction from the other wires, but the writer has heard breathing half a mile distant, and a distinguished physician present at the time expressed his firm belief that the telephone would become a valuable agent in tracing out all diseases connected with respiration. The stethoscope has found a powerful ally."—*Manchester Guardian*, Dec. 3, 1877.

TELEPHONES IN BARRACKS.

"The telephone is being rapidly introduced into the various military establishments, not only in the capital and its neighbourhood, but also elsewhere in Germany. At Dresden one of the new instruments has been arranged between the commandant's office and the arsenal and barracks of the rifles, about 800 yards distant. An already existing telegraph wire is utilised, from which wires are further led to telephones in four rooms in the barracks. The apparatus is reported to act perfectly, conversations being carried on without the slightest difficulty. In Austria, also, experiments, the result of which is stated to have been exceedingly satisfactory, have been made in Vienna, with the telephone."—*Pall Mall Gazette*, Dec. 28, 1877.

W. H. PREECE, Esq.,* ON THE TELEPHONE.

". . . . At present, the apparatus in use for field telegraphy is the ordinary Morse recording apparatus, which records its messages in the ordinary dot and dash alphabet, understood only by the initiated, supplemented by a sounding instrument, which appeals, by a similar foreign language, to the ear. Thus, to convey intelligence from one point to another, a message has to be written down on paper, it has then to be translated by a telegrapher into the *Morse* language, which has to be re-translated at the distant end into the ordinary written language, and then read by the recipient. These operations are subject to error, and have not secured faith in their reliability. Is there any commanding officer here present who would not wish such an uncertain agent in a very warm place? Those who were present at the Autumn Manœuvres on Salisbury Plain know how to value its services.

* Vice-President of the Society of Topographical Engineers, and Member of Institution of Civil Engineers.

It is unquestionable that the telegraph has not inspired confidence, and this is due as much to its natural uncertainty as to the want of knowledge of the tool that is used. Accuracy in the transmission of orders is the *sine quâ non* of a military telegraph. We know of one great disaster that arose from a mistake. 'Some one has blundered.' It was the very last thing determined upon in our late Ashantee War, and the rapidly collected materials drawn from the Post Office stores were despatched at the last moment, by passenger train, and stowed in the officers' baggage room. Yet we have the authority of Sir Linton Simmons for saying that the operations in that war could not have been carried on as they were without its assistance, and that it was productive of very great economy to this country by shortening the expedition and enabling the greatest amount of benefit to be derived from the materials and means that were placed at the disposal of the General in command.

"Now, the telephone will place in the hand of every officer an instrument which will transfer the actual words and tones of his own voice to his correspondent at any reasonable distance. I have spoken distinctly, at various distances up to ninety miles, and I have been able to recognise, with absolute certainty, the voices of different people at sixty-seven miles. It will solve the moot question as to the best form of instrument for military telegraphs, about which there is much diversity of opinion. . . . . How far the telephone can be utilized for naval purposes remains to be seen. Wherever a wire can extend, there can the voice be sent. In communicating between the bridge and the wheel, between the turret and the engine room, between the look-out and the officer of the watch, it ought to be useful. For diving operations it is invaluable. In torpedo operations and range-finding it may prove useful. Probably no instrument that has ever been devised has created more sensation, or has attracted so much attention, as the incomparable invention of Alexander Graham Bell."—*From a lecture delivered before the United Service Club, December*, 1877.

THE TELEPHONE AT THE CRYSTAL PALACE.

"Some very interesting experiments were tried with the wonderful telephone at the Crystal Palace on Boxing Day, a day when, as everybody knows, the Palace is crowded with more or less noisy persons. Above the heads of fifty thousand persons who congregated at the Palace, and the consequent noise created below, the operators at each end of the wire, which was over a quarter of a mile in length, did not experience the slightest difficulty in carrying on a conversation with each other. In every instance where the telephone was made use of by the visitors, they expressed themselves delighted with the ease with which they could converse. The arrangements in connection with the construction of the wires were under the superintendence of Mr. Frank Fisher." —*Daily News*, December 29, 1877.

LAW TELEPHONE.

"The aid of the telephone is being secured in Jersey City in connection with the courts. A telegraph wire is being laid from the Hudson County Court House to the telegraph office in Montgomery Street, and a telephone will be attached to each end, whereby lawyers can communicate with each other rapidly between their offices and the court house."—*New York Herald*, Dec. 30, 1877.

A JOURNALISTIC LUXURY.

"General Hawley, Charles Dudley Warner, and S. A. Hubbard, editors of the *Hartford Courant*, U.S., have acquired the journalistic luxury of a telephone, which connects their houses and enables them to exchange and edit their views at home, and have their articles all ready for the compositors when they reach the office."—*Anglo-American Times.*

CHESS BY TELEPHONE.

According to an account of the *Hartford Times* (Connecticut, U.S.) the telephone has already been utilised for transmitting the moves of a chess game. The parties to the contest, which took place at Hartford, were Mrs. J. W. Gilbert, the lady champion of America, and Mr. J. G. Boldon, on the one side, and Messrs. A. E. Olmstead and C. G. Lincoln on the other. The novel way of carrying on the game created a great deal of amusement amongst the members of the Hartford chess circle, who in separate parties attended at the two stations, which were miles apart; and the powers of the telephone for purposes of general conversation were often tried during the intervals between the announcement of the moves.

INTERESTING EXPERIMENTS IN IRELAND.

"Some interesting experiments with the telephone were tried yesterday on the Midland Great Western Railway. The chairman and directors of the line, having kindly placed the telegraphic wires of the company between Enfield and Edenderry stations at the service of the experimenters, Mr. Thomas H. Sanger, Irish Divisional Engineer of the Postal Telegraph Service, repaired to Enfield accompanied by Messrs. Wm. Louth, James Walby, H. Pomery, of the Telegraph Department; John A. Baker, F.R.C.S.I., and J. E. Ward, Midland Great Western Railway. . . . To test the powers of this wonderful little instrument Mr. Sanger sang a verse of a well-known song at Edenderry, every note of which was heard most distinctly at Enfield; also a tune whistled at the former place was clearly heard at the latter. On the return of the party to Enfield the powers of the telephone were proved in an extraordinary manner. The observatory clock is electrically moved by a wire from the Port and Dock's clocks in Dublin running through Broadstone Station, for about three miles along the Midland Great Western Railway, and thence to Dunsink Observatory. The telephone was

attached to the wire between Dublin and Mullingar, quite distinct from the wire leading to the Dunsink Observatory clock. Under these circumstances the induction from that wire clearly made each beat of the Observatory clock perfectly audible at Enfield. . . . What was experienced yesterday proves that all that has been read and heard of this remarkable invention is perfectly true and that before long the telephone will on many lines take the place of the electric telegraph."—*Saunders's News Letter, Dublin*, January 1st, 1878.

WHISPERING BY TELEPHONE.

"On Tuesday morning some highly successful experiments were made with the telephone between the Railway Station, at Ipswich and the Liverpool Street Station, London, a distance of 68¾ miles. At Ipswich the operator was Capt. Turner, R.E., who was accompanied by a party of about sixteen, amongst whom were Mr. J. Dutton, district superintendent, and Mr. Nibloe, station master. At London, Mr. Sach, manager of the Great Eastern Railway telegraph system, was the operator, and with him were two of his assistants. Three different kinds of telephones were used, the box pattern, and two of the smaller pattern instruments. The ordinary telegraph wires were brought into requisition, and conversation was most easily kept up. Bugle calls were also distinctly heard at London, and a tune sung by Mr. Sach was perfectly distinguished at Ipswich. It was so good that about half-a-dozen of the party called out "Hear, hear," upon which Mr. Sach asked them not to do that again, or they would split his ear-drum. This caused a laugh, which, as well as a slight cough—a mere phthisic, in fact—was heard at Liverpool Street, and when Mr. Sach sneezed, the listeners at Ipswich heard him. Then further experiments were tried. First two persons were placed in circuit, and as the words of Capt. Turner could be distinguished in London, the number of persons was increased to eleven, and still conversation could be easily maintained. The marvel of the experiments, however, was still to come. Capt. Turner gradually lowered the tone of his voice till he spoke much below ordinary conversation pitch, and very little higher than a whisper, and even then Mr. Sach heard what was said, and repeated the words. Mr. Sach also tried the same thing, but as the instruments at Ipswich were not so sensitive as the one he was using, the words could not be so easily heard, but still sufficiently clear to gather the meaning. This startled the whole party, as such a thing was never anticipated. As a conclusion the operators bade each other good night, and gave a cheer. That at London was distinctly heard in the room at Ipswich, even by those who had not telephones against their ears. The experiments began at half past ten and lasted with unflagging interest until twelve o'clock, and all expressed themselves thoroughly pleased with the results. It is most gratifying to the operators that they have so far advanced the efficiency of the telephone, and that they have so demonstrated the use to which they can be put. Of the instruments used at Ipswich the box pattern was the most effective."—*East Anglian Daily Times*, Jan. 2, 1878.

THE TELEPHONE AT COURT.

"On Monday evening, as announced in the Court Circular, Professor Bell and Colonel Reynolds were presented to the Queen, and exhibited the telephone, being assisted by Mr. C. Wolleston. In a lecture of fifteen minutes' duration, Professor Bell explained the mechanism of his invention, and then held telephonic communication with Osborne Cottage, the residence of Sir Thomas Biddulph. The apparatus there was under the management of Mr. F. C. Ormiston, who was the first to address the Royal party. Her Majesty conversed with Sir Thomas and Lady Biddulph, and later Miss Kate Field, who was at Osborne Cottage, sang "Kathleen Mavourneen," for which Her Majesty returned gracious thanks telephonically through the Duke of Connaught. Miss Field afterwards sang Shakespeare's "Cuckoo Song," and "Comin'

Thro' the Rye," and delivered the epilogue to "As You Like It," all of which were heard distinctly. The applause which followed came through the telephone. The Princess Beatrice, the Hon. Mrs. Ponsonby, and others conversed with Osborne Cottage, sometimes through a circuit of one, three, and five persons. As the evening wore on, telephonic connection was established between Osborne House and Cowes, Southampton, and London. At Cowes, where Major Webber, of the Royal Engineers, superintended the line, a quartet of tonic-sol-fa singers, consisting of Miss Webber, Miss Strohmenger, Mr. Hamilton, and Mr. Curwen, sang several part songs, which produced an admirable effect, and the Duke of Connaught talked for several minutes with Major Webber. Attention was then turned to Southampton, where Mr. W. H. Preece, of the Post Office, talked as fluently with Professor Bell and Colonel Reynolds as though he were in the next room. A bugle in Southampton sounded the retreat with startling distinctness; and, lastly, came the tones of an organ from London, in charge of Mr. Wilmot. The experiments lasted from half-past 9 until nearly midnight. Her Majesty, the Princess Beatrice, the Duke of Connaught, and the entire Royal Household evinced the greatest interest. On Tuesday Professor Bell made very successful experiments between Cowes, Osborne House, and Osborne Cottage, at which the Princess Beatrice, the Duke of Connaught, the Duke of Richmond, Lord John Manners, Lord Ripon, Lady Biddulph, Lady Cowell, Sir John Cowell, and others, assisted."—*Times*, Jan. 16, 1878.

THE QUEEN AND THE TELEPHONE.

"Osborne, *Jan.* 16, 1878.

"My dear Sir,—I hope you are aware how much gratified and surprised the Queen was at the exhibition of the telephone here on Monday evening. Her Majesty desires me to express her thanks to you and the ladies and gentlemen who were associated with you on the occasion. The Queen would like, if

there is no reason against it, to purchase the two instruments which are still here with the wires, &c., attached. Perhaps you will be so kind as to let me know to whom the sum due should be paid.—I am, my dear Sir, very faithfully yours,

"Thos. Biddulph."

"Prof. Alex. Graham Bell."

A SCIENTIFIC WONDER.

"On Wednesday last a demonstration of the practical application of the uses of the newly-invented instrument for conveying the human voice, which is known as the telephone, was given at 115, Cannon Street, E.C. The apparatus employed on this occasion may be likened to a small writing desk, having in front of the telephonic operator an electric bell, which can be sounded by the correspondent at the other extremity of the telegraphic wires; there is also a stud which, when pressed, sounds a second electric bell on the distant correspondent's instrument, to call his attention to the impending message. On both sides of the desk are funnel-shaped wooden instruments, the wider end of one of which is applied to the mouth when sending a message, and the other to the ear when receiving one. The smaller end of each instrument is continued into a wire, which is in direct communication with the similar apparatus at which the distant correspondent sits.

"To transmit a verbal message by the telephone, the sender first touches the electric stud, which causes the bell to sound at the other end of the wire. This may be a few hundred yards or miles distant. He then takes up the two instruments, and as they are raised from their supports their removal relieves a spring, which at once cuts off the wires from the electric bell, and leaves them free to convey the telephonic message. Then, placing one of the instruments to the mouth, the message is spoken, and is received by the distant listener, who has his instrument applied to his ear; and his reply is conveyed back and received in a similar manner.

"The voice, when spoken into the mouth of the funnel-shaped instrument, is received on a vibrating membrane, constructed on the same principle as the membrane of the drum of the ear. The vibration of this membrane interrupts the electric current which is proceeding along the wire from a small magnet contained in the instrument held in the hand. These interrupted vibrations are reproduced in the corresponding instrument held in the hand of the distant listener; and the sound there created is the consequence of the vibrations induced in the membrane of that instrument.

"Contrary to the general belief, the telephone does not convey, so to speak, the actual voice or sound, as is really done in the toy sold in the streets, which is formed by a tightened string, stretched between two small drums made of parchment and the necks of two broken bottles. In the telephone the vibrations of sound interrupt an electric current, and at the other end that interrupted current reproduces the vibrations, and consequently re-creates the sound.

"The demonstrations were perfectly successful: conversation was easily maintained with a distant operator in some other part of the city; the very tones and inflexions of the voice were exactly reproduced; an angry or affectionate message could be sent with appropriate emphasis; and one or two of the ladies present indulged in mild flirtations with the unseen correspondent, sending out soft suspirations, and receiving vigorous osculations in return.

"The utility and convenience of such an invention are obvious. Instead of sending a telegraphic message, requiring time to write, and a skilled operator to transmit, one has but to whisper into the telephone, which, like a speaking tube practically unlimited in length, will convey the message to its required destination. That the telephone will come into general use there is not the slightest doubt. At present it is in its infancy; but the company established by Professor Bell is already engaged in supplying instruments.

"The success of the telephone in conveying messages great distances was shown in the experiments recently performed before Her Majesty at Osborne, when a conversation was

carried on between London and the Isle of Wight, and vocal and instrumental music was transmitted with success."—*The Field*, January 19, 1878.

A LIFE SAVED BY TELEPHONE.

"*Newport, R. I., Jan.* 19.—A sad drowning accident occurred at Easton's Pond, Middletown, this afternoon. Four boys, while skating, broke through the ice, which was very rotten. Two, sons of Colonel O. L. Shepherd, U. S. A., got out without assistance. Charles Easton was pulled out when he had gone down for the last time. William Riggs, Jr., aged 10 years, was not found until after Easton had been rescued. Life was extinct, and the body was taken to his parents' residence. The boy Easton owes his life to the telephone, word being sent to town by this means for a physician. Had the news reached this city by ordinary means, there would have been two deaths instead of one to record."—*Special Despatch to Boston Herald, U.S.* Jan. 20, 1878.

THE TELEPHONE AT THE HOUSE OF COMMONS.

"Communication was established between the House of Commons and the office of the *Daily News* in Bouverie Street by means of the telephone, which is specially attached to the ordinary telegraphic wires running between the Houses of Parliament and the *Daily News* office. Conversation was distinctly audible despite the noise from the other wires, and part of the Parliamentary debate and summary in this morning's paper was received by this novel and interesting agency."—*Daily News*, Jan. 23, 1878.

A TRIBUTE TO GENIUS.

"In consideration of his invention of the telephone, Professor Alexander Graham Bell has been elected a life member of the Society of Arts."—*Journal of the Society of Arts*, February 15, 1878.

BELL'S TELEPHONE.

THE ELECTRIC TELEPHONE COMPANY,

115, CANNON STREET, E.C.,

IS NOW READY TO EXECUTE ORDERS

FOR THE

Rental or Purchase of Telephones.

ESTIMATES

ARE ALSO FURNISHED

For the CONSTRUCTION of TELEPHONIC LINES.

Local Companies will be established in all the principal Towns of the United Kingdom.

The public is hereby cautioned against purchasing or using cheap imitations of Bell's Telephone, as they are infringements of Professor Bell's Patent. All makers, sellers, or users of such spurious instruments will be prosecuted to the full extent of the law.

BELL'S TELEPHONE.

THE Telephone has made rapid progress, commercially, many leading merchants, bankers, and manufacturers having already adopted it. As a means of rapid communication, Professor Bell's invention is found superior to all known systems of telegraphy, proof of the fact being found in the following letters :—

"CHAPEL FIELD WORKS,
"ARDWICH, MANCHESTER,
"*Jan.* 29, 1878.

"DEAR SIRS :—In reply to your favour, we have much pleasure in advising you that we have had Bell's Telephone in constant use for the past three months, during which time we have experienced every possible convenience from them as practically applied to commercial purposes. We have twenty-four telephones in circuit from our head offices, communicating with the various departments, and the facilities which it gives to business are very great—in fact, we daily experience immense advantages by this wonderful system of communication.

"We are, yours obediently,

(Signed) "DAVID MOSELEY AND SONS.

"ELECTRIC TELEPHONE COMPANY,
"115, CANNON STREET, E.C."

"NORTHERN TELEGRAPH WORKS,
"SQUARE ROAD AND CHARLES STREET, HALIFAX,
"*Feb.* 13*th*, 1878.

"DEAR SIRS :—We have much pleasure in stating that we find the telephone of the utmost importance in commercial telegraphy, and infinitely better than any other telegraphic instrument extant, both as regards speed of transmission, accuracy, and small cost of maintenance. In every case where we have fixed the instrument, it is working satisfactorily, and many other instruments are being laid aside altogether after a few days' trial of the telephone.

"We may add that we are working lines from one quarter of a mile to ten miles in length successfully, although many of these are fixed on the same posts as other lines worked by other classes of instruments. A few weeks ago, one of our lines between this town and Bradford (about ten miles) became so faulty, that communication by the Wheatstone or other instruments was impossible, and the line would have been useless for the time, had we not tried the telephone, which, to our surprise, worked perfectly.

"We have since made experiments on a number of faulty lines, both overground and underground, and find that the telephone may be worked over a line too far gone for any other telegraphic instrument.

"We are, dear sirs, yours most respectfully,

"BLAKEY BROS., AND EMMOTT.

"ELECTRIC TELEPHONE COMPANY,
"115, CANNON STREET, E.C."

Further proof of the practical value of the Telephone may be found in the following list of persons, companies, and institutions now using it :—

LONDON.

J. S. MORGAN & Co., Bankers, Old Broad Street.
MARINE INSURANCE Co., Old Broad Street.
INDIA RUBBER Co., 106, Cannon Street.
NASH & FIELD, 12, Queen Street.
BROWN'S HOTEL, Dover Street.
ADAMS & Co., Marshall Street.
JAMES DUNCAN, Clyde Wharf, Victoria Docks.
"DAILY NEWS" OFFICE.
H.M. POST-OFFICE.
H. F. GILLIG & Co., 449, Strand.
SIR JOHN HAWKSHAW.
ROYAL POLYTECHNIC INSTITUTION, Regent Street.
ROYAL AQUARIUM, Westminster.
LONDON & NORTH WESTERN RAILWAY Co.
LONDON & SOUTH WESTERN RAILWAY Co.
MAJOR WOOD, Brazilian Telegraph Co.
THE PERSIAN AMBASSADOR, Holland Park.
ANTHONY GIBBS, Esq., 16, Hyde Park Gardens.
WM. BLACKMORE, Esq., Founders' Court, E.C.

COUNTRY.

WINDSOR CASTLE AND OSBORNE HOUSE.

LORD DERBY, Knowsley Park, Lancashire.
LORD ONSLOW, Clandon Park, Guildford.
LORD LINDSAY, Dun Echt, Aberdeen.
REV. H. WILDER, Sulham, Reading.
CAPT. HERBERT, H.M.S. "Vernon," Portsmouth.
THE MIDLAND & GREAT WESTERN RAILWAY Co., Ireland.
THE AQUARIUM, Yarmouth.
J. CROSSLEY & SONS, Limited, Halifax.
SCARBOROUGH BROS., Halifax.
JOHN EDDISON, Esq., Leeds.
SYMES & Co., Liverpool.
D. MOSELEY & SONS, Manchester.
J. AKERN, Manchester.
C. CLIFFORD & SONS, Birmingham.
CRYSTAL PALACE, Sydenham.
STREET & Co., Belper.
"FREE PRESS" Office, Bury St. Edmunds.
H. E. FALCK, Esq., Winsford.
A. WESTWOOD & Co., West Bromwich.
GRIFFITHS & Co., Derwent Tin Plate Works, Workington.
MAGUIRE & Co., Dublin.
T. MACKENZIE & SONS, Dublin.
PINNER BROS., & Co., Dublin.
CLELLAND & Co., Belfast.
CARVILL BROS., Newry.
H. PARKINS, Esq., Rugby.
R. ROBERTS, Esq., Portmadoc.
R. S. ARMITAGE, Esq., Nottingham.
ROBERT BAILEY, Esq., Torr Grove, Plymouth.

OFFICE of THE ELECTRIC TELEPHONE COMPANY:

115, CANNON STREET, E.C.

LONDON:
BRADBURY, AGNEW, & CO., PRINTERS, WHITEFRIARS.